VIGNAN'S
FOUNDATION FOR SCIENCE, TECHNOLOGY & RESEARCH
(Deemed to be University) - Estd. u/s 3 of UGC Act 1956

Programme Educational Objectives (PEOs)

PEO 1: Develop diverse capability to work with tractor and implement manufacturing industries, seed processing industries, irrigation and drainage companies and also to run self-entrepreneurship like dairy farming and custom hiring centers.

PEO 2: Take up higher studies in reputed institutes and motive towards innovative research by applying their skills in agricultural water management, farm machinery and power, processing and energy management systems in agriculture.

PEO 3: Understand the issues of ethics, safety, professionalism, cultural diversity, globalization, environmental impact and responsibility of serving the society and the environmental issues.

Programme Specific Outcomes (PSOs)

Graduates in Master's degree will be able to:

PSO 1: To utilize adequate knowledge in farm machinery and power engineering and to possess the competency to qualify various exams as well as to gain better employment opportunity in various industries.

PSO 2: To gain the proficiency by using the expertise to design and develop the farm machineries and implements as per the need of the area and farmers and come out with solution through farm power for smart agriculture.

PSO 3: To develop skills necessary to design, modify and direct for the manufacturing of agricultural machinery and implement for different agricultural production systems.

PSO 4: To abreast the students with mathematical, experimental and computational skills for solving different field problems.

PSO 5: To equip the students with technical knowledge and skills required for the operation, maintenance and evaluation of Tillage, Sowing and intercultural operational machinery needed for agricultural farms.

Student Outcomes (SOs)

SO 1: An ability to design and conduct experiments, as well as to analyze and interpret data

SO 2: An ability to design a system, component, or process to meet desired needs within

realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

SO 3: The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

SO 4: A recognition of the need for, and the ability to engage in, life-long learning

SO 5: Proficiency in mathematics, through differential equations, and relevant engineering sciences consistent with the discipline

SO 6: Knowledge of appropriate agricultural, and/or biological sciences, and/or natural resource topics

SO7: Competencies in relevant fields such as: biological materials, computer and automatic control systems, information systems, machine systems, modified environment design, natural resource systems, processing systems, and structural design

Programme Outcomes (POs)

The graduates of Computer Science and Engineering will be able to:

PO 1: Engineering knowledge: Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

PO 2: Problem analysis: Identify, formulate, research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

PO 3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.

PO 4: Conduct investigations of complex problems: using research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of information to provide valid conclusions.

PO 5: Modern tool usage: Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO 6: The engineer and society: Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.

PO 7: Environment and sustainability: Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PO 9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.

PO 11: Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life- long learning in the broadest context of technological change.

PO 12: Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

M.Tech. FM

R22 C22 - COURSE STRUCTURE

Pre - Semester

Course Code	Title of the course	L	T	P	C	Course type
	Orientation Session	0	2	0	1	Binary graded
	IT workshop and cyber security	0	0	2	1	Binary graded
	Total	**4**			**2**	

I Year I Semester

Course Code	Title of the course	L	T	P	C	Course type
22FMB101	Soil Dynamics in Tillage and Traction	2	2	2	4	Professional Core
22FMB102	Design of Tillage and Planting Equipments	2	2	2	4	Professional Core
22FMB103	Farm Power and Machinery Management	2	2	2	4	Professional Core
	Department Elective	2	2	2	4	Elective
	Teaching Assistantship	0	0	2	1	Binary graded
	Indian Knowledge System	0	2	0	1	Binary graded
	Work-in-lieu of a course*				2	Elective & Floating Credit
	Sub Total				**20**	
	Add on course -1				3	
	Total				**23**	

I Year II Semester

Course Code	Title of the course	L	T	P	C	Course type
22FMB104	Design of Plant Protection and Harvesting Equipments	2	2	2	4	Professional Core
22FMB105	Testing and Evaluation of Tractors and Farm Equipments	3	0	2	4	Professional Core
	Department Elective				4	Elective
	Department Elective				4	Elective
	Research Methodology and IPR	1	2	0	2	Interdisciplinary
	Interdepartmental Project	0	0	2	1	Project
	Teaching Assistantship	0	0	2	1	Binary graded
	Sub Total				**20**	
	Add on course -2				3	
	Total				**23**	

II Year I Semester

Course Code	Title of the course	L	T	P	C	Course type
	Internship / Project	0	2	24	13	Project
	Sub Total	**0**	**2**	**24**	**13**	
	Add on course -3 (MOOCs Course)				3	
	Total				**16**	

II Year II Semester

Course Code	Title of the course	L	T	P	C	Course type
	Internship / Project	0	2	24	13	Project
	Sub Total	**0**	**2**	**24**	**13**	
	Add on course -4 (MOOCs Course)				3	
	Total				**16**	

VIGNAN'S
FOUNDATION FOR SCIENCE, TECHNOLOGY & RESEARCH
(Deemed to be University) - Estd. u/s 3 of UGC Act 1956

DEPARTMENT OF AGRICULTURAL ENGINEERING

DIVISION OF FARM MACHINERY

MANDATORY COURSES

S.No.	Course Code	Name of the course	L	T	P	C
1.	22FMB102	Design of Tillage and Planting Equipments	2	2	2	4
2.	22FMB104	Design of Plant protection and Harvesting Equipments	2	2	2	4
3.	22FMB101	Soil Dynamics in Tillage and Traction	2	2	2	4
4.	22FMB105	Testing and Evaluation of Tractors and Farm Equipments	3	0	2	4
5.	22FMB103	Farm Power and Machinery Management	2	2	2	4

ELECTIVE COURSES

S.No.	Course Code	Name of the course	L	T	P	C
1.	22FMB801	Ergonomics and Safety in Farm Operations	2	0	2	3
2.	22FMB802	Applied Instrumentation in Farm Machinery and Stress Analysis	2	0	2	3
3.	22FMB803	Tractor Design	2	0	2	3
4.	22FMB804	Power Hydraulics	2	0	2	3
5.	22FMB805	Land Grading and Earth Moving Machinery	2	0	2	3
6.	22FMB806	Horticulture and Forestry Equipment	2	0	2	3
7.	22FMB807	Controlled Environment Agriculture	2	0	2	3
8.	22FMB808	Product Manufacturing Technology	2	0	2	3
9.	22FMB809	Farm Machinery Dynamics, Noise and Vibration	2	0	2	3
10.	22FMB810	Engineering Properties of Food Materials	2	0	2	3

11.	22FMB811	Geo-informatics and Nano-Technology for Precision Farming	**2**	**0**	**2**	**3**
12.	22FMB812	Dimensional Analysis and Similitude	**2**	**0**	**2**	**3**
13.	22FMB813	Machinery for Horticulture and protected agriculture	**2**	**0**	**2**	**3**
14.	22FMB814	Machinery for Precision Agriculture	**2**	**0**	**2**	**3**
15.	22FMB815	Foundation skills in integrated product development	**2**	**0**	**2**	**3**

ADD-ON CERTIFICATION COURSES

S.No.	Course Code	Name of the course	L	T	P	C
1.		Machine Learning for Soil and Crop Management	**3**	**0**	**0**	**3**
2.		Applied Optimization for Wireless, Machine Learning, Big Data	**3**	**0**	**0**	**3**
3.		Advanced Robotics Applications	**3**	**0**	**0**	**3**
4.		Principles Of Vibration Control	**3**	**0**	**0**	**3**
5.		Energy Conversion Technologies (Biomass And Coal)	**3**	**0**	**0**	**3**
6.		Remote Sensing and GIS for Rural Development	**3**	**0**	**0**	**3**
7.		Energy Resources, Economics, and Sustainability	**3**	**0**	**0**	**3**
8.		Traction Engineering	**3**	**0**	**0**	**3**
9.		Sensors and Actuators	**3**	**0**	**0**	**3**
10.		Applied Ergonomics	**3**	**0**	**0**	**3**

M.Tech Coordinator **Head of the Department**

SYLLABUS

MANDATORYCOURSES

22FMB101 - SOIL DYNAMICS IN TILLAGE AND TRACTION

Hours per week:

L	T	P	C
2	2	2	**4**

PREREQUISITE KNOWLEDGE:

Acquaintance of basic knowledge about tillage equipment's and soil mechanics.

COURSE DESCRIPTION AND OBJECTIVES:

To acquire knowledge regarding mechanics of tillage tools, scouring of soil and importance, determine Kc and Kϕ using plate shrinkage test, wheel slip and its role in traction mechanism, slip measurement and slip control method, rolling resistance and effect of tyre size inflation pressure and lug height on tractive performance, study of effect of soil compaction by agricultural machinery.

MODULE-1

UNIT-1 **6L+6T+6P=18 Hours**

Mechanics of tillage tools: Introduction: Inclined, Vertical, Wide blades, Cutting of soil. Scouring of soil and its importance, Soil compaction by Agricultural machines and Tractors. Remedies for soil compaction. Techniques for measuring terrain values and load sinkage relationship.

UNIT-2

Determination of Kc and Kφ using plate sinkage test. Shear stress, displacement relationship in sinkage and horizontal deformation, slip, sinkage and vertical load.

PRACTICES:

1. To study the effect of soil compaction by agricultural machines.
2. Determination of soil movement on M.B. Plough.
3. To study about wheel slip of tractor in field conditions.

4. Determination of soil movement on Disc Plough

MODULE-2

UNIT-1 **18L+18T+18P= 54 Hours**

Motion resistance of a rigid wheel and a track. Tractive efforts developed by a wheel and a track. Wheel slip and its role in traction mechanics.

UNIT-2

Slip measurement and slip control method. Mobility number and effect of mobility number on tractive effort. Rolling resistance and effect of tyre size inflation pressure and lug height on tractive performance.

UNIT-3

Performance and power analysis of tractor, matching of power, weight, speed and slip to obtain optimum power transmission. Cost analysis of machinery, selection of optimum machinery and replacement, case studies of agriculture mechanization.

PRACTICES:

1. Measurement of terrain parameters required for tractive performance for prediction of off–road vehicles.
2. Determination of pull-slip curve for a tarmacadam and field condition.
3. Determination of pull-slip curves for a farm tractor on different terrains.
4. Study of rolling resistance and tractive efficiency of rigid, pneumatic and track types vehicles.

COURSEOUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Estimate the soil compaction for different types of machines in the field.	Evaluate	1	1,2,4,5,6,8,9,10
2	Analyse the different techniques to measure the terrain values.	Analyse	1	1,2,6,8,10
3	Estimation of Kc and Kφ values for different soils	Evaluate	1	1,2,4,5,6,8,9,10
4	Analyse the impact of tyre inflation pressure on slippage	Analyse	2	1,2,6,8,10,11

5	Analyse the effect of various parameters on optimum power transmission	Analyse	2	1,2,6,8,10,11,12

MAPPING OF SUSTAINABLE DEVELOPMENT GOALS (SDGs) AND INDIAN KNOWLEDGE SYSTEM (IKS):

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 2 – Zero Hunger	Traditional farming practices (e.g., multi-cropping, indigenous plough designs) integrated with modern tools.
SDG 7 – Affordable & Clean Energy	Ancient practices of energy efficiency in irrigation (Persian wheels, bullock-driven devices).
SDG 9 – Industry, Innovation & Infrastructure	Indigenous innovations in agricultural implements as foundation for modern design.
SDG 12 – Responsible Consumption & Production	Traditional sustainable practices in soil conservation and minimal resource wastage.
SDG 13 – Climate Action	Traditional water harvesting, soil fertility management, and eco-friendly farming practices.
SDG 15 – Life on Land	Vedic and Ayurvedic references to soil as a living system, emphasizing balance with nature.

TEXT BOOKS:

1. Gill, W. R. And Vanden Berg, Soil Dynamics in Tillage, Hand book No.316, US Department of Agriculture, 1998.
2. Wong, J. Y. Theory of Ground Vehicle, John Willey & Sons, New York, 2008.

REFERENCE BOOKS:

1. Bekker, M. G. Theory of Land Locomotion, University of Michigan Press, USA, 2006.
2. Bekker,M. G. Off-Road Locomotion, University of Michigan Press USA, 2009.
3. Bekker, M. G. Introduction of Terrain Vehicle System, Michigan, USA, 1999.
4. Karafaith, L. L. and A. A, Nowatzki, Soil Mechanics for Off–Road Engineering, Tran Tech. Pub. Switzerland, 1998.
5. Mohesin N. N. 2000. Physical properties of plant and animal materials "Gorden & Breach Science Publishers, New York.

SKILLS:

- Measurement of tractive performance of off-road vehicles
- Measurement of soil compaction of off-road vehicles



Image source link:
https://th.bing.com/th/id/OIP.ev7khOITx1J8cm7iWc8AmQHaJ4?rs=1&pid=ImgDetMain
Image file name: Soil Dynamics in Tillage and Traction

22FMB102 - DESIGN OF TILLAGE AND PLANTING EQUIPMENT

Hours per week:

L	T	P	C
2	2	2	**4**

PREREQUISITE KNOWLEDGE:

Fundamentals of design criteria and basic knowledge of different agricultural machines

COURSE DESCRIPTION AND OBJECTIVES:

To learn about farm machinery design principles, design of working components of M.B. plough, secondary tillage equipment, types of metering devices and their working, and safety devices for tractor and farm implements.

MODULE-1

6L+6T+6P=18 Hours

UNIT-1: FARM MACHINERY DESIGN PRINCIPLES

Introduction of Engineering design, farm machinery design, design parameters of farm machinery, modern farm machines. Design of power transmission components and systems in Agricultural machines.

UNIT-2: DESIGN OF PRIMARY TILLAGE IMPLEMENTS

Design of working components of a M.B. Plough: Share, forces acting on the M.B. plough. Design of working component of a disc plough: disc and forces acting on discs of disc plough.

PRACTICES:

1. Statement and formulation of design problems.
2. Design of share of Mould board plough.
3. Design of disc plough.
4. Force analysis on tillage implements and location of center of resistance on M.B. plough

MODULE-2

18L+18T+18P=54 Hours

UNIT-1: DESIGN OF SECONDARY TILLAGE EQUIPMENT

Disc harrow, cultivators, Seeding machines: Types of metering devices and their working.

UNIT-2: DESIGN OF SECONDARY TILLAGE EQUIPMENT

Procedure of design of fluted roller, horizontal plate type metering devices and seed and fertilizer boxes.

UNIT-3: DESIGN FOR SAFETY AND RELIABILITY

Safety devices for tractors and farm implements. Cabs & HVAC designs- designs of ROPS and FOPS, safety locations of PTO. Reliability criteria in design of farm/seed to management machinery and its application. Development of product reliability

PRACTICES:

1. Statement and formulation of design problems.
2. Design of share of mould board plough.
3. Design of disc harrow.
4. Design of seed metering mechanism.
5. Design of seed hopper for seed drill.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Application of design principles in agricultural machinery	Apply	1	1,5,6,8
2	Design of mould board plough	Create	1	1,3,4,5,9
3	Analysis of different types forces acting on mould board plough	Analyse	1	1,2,4,6,7
4	Design of seeding machines and different	Create	2	1,2,3,4,5,8,12

	types of metering mechanisms			
5	Analyse the reliability criteria in design of farm machinery	Analyse	2	2,4,5,6,7,11

MAPPING OF SUSTAINABLE DEVELOPMENT GOALS (SDGs) AND INDIAN KNOWLEDGE SYSTEM (IKS):

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 2 – Zero Hunger	Indigenous plough designs (nati plough, wooden ploughs) and traditional sowing practices form the base for modern implements.
SDG 7 – Affordable & Clean Energy	Traditional use of animal power and water wheels demonstrates sustainable low-energy solutions.
SDG 8 – Decent Work & Economic Growth	Ancient guild systems and cooperative farming models emphasize collective prosperity.
SDG 9 – Industry, Innovation & Infrastructure	Indigenous innovations in tools and implements have always been foundations for rural industries.
SDG 12 – Responsible Consumption & Production	Traditional emphasis on durability (iron-smithy tools, seed preservation) supports eco-friendly design.
SDG 13 – Climate Action	Ancient soil fertility management (composting, crop rotation) highlights eco-conscious farming.
SDG 15 – Life on Land	Vedic and Ayurvedic texts treat soil as a living system, stressing harmony with land resources.

TEXT BOOKS:

1. Sharma, D. N. And Mukesh S. Farm Machinery Design. Principles and problems. Jain Brothers, East Park Road, New Delhi, 2010.
2. Kepner R. A., Bainer Ray and Barger E. L. Principle of Farm Machinery, AVI Pub., 1 Jan 2005.
3. Varshney A.C. Data Book for Agricultural Machinery Design, Central Institute of Agricultural Engineering, 2004.
4. Kurtz. G., Thompson, L. and P. Claar. Design of Agricultural Machines, John Willey and sons, 1994.

REFERENCE BOOKS:

1. Ralph Al cock. Tractor Implement System. AVI Pub.1996.
2. Bernacki, H. Kanafozski, O and T. Karvowski. Agriculture machines. Theory and Construction. Vol. I and II, translated and published by US Dept. of Agriculture,

1996.

3. Bosoi, E. S. Vermiaev, O V, S Mirnov, I.I. and Sultan–Shakh, E. G. Theory, construction and calculation of agriculture machines, A. A Balkema Pub. Rotterdam, 1998.
4. Gyachev, L. V. Theory of surfaces of plow bottoms, A. A Balkema Pub., Rotterdam, 1997.
5. Nartov, P. S. Disc Soil Working implements, A. A. Balkema Pub. Rotterdam, 1996.

SKILLS:

- Design of primary tillage equipment
- Design of secondary tillage equipment



Image source link: https://www.deere.com/assets/images/region-4/products/attachments/attachments-and-implements/utiilty-tractor-attachments-accessories/frontier-tillage-hero-r4d000207.jpg
Image file name: Design Of Tillage and Planting Equipment

22FMB103 - FARM POWER AND MACHINERY MANAGEMENT

Hours per week:

L	T	P	C
2	2	2	**4**

PREREQUISITE KNOWLEDGE:

Fundamental use of different powers in agriculture and basic machineries used for farm operations.

COURSE DESCRIPTION AND OBJECTIVES:

To acquaint with importance of farm mechanization in Indian agriculture, estimation of operating cost of tractor and farm machinery, tractor power performance, selection of farm machinery and selection of proper power.

MODULE-1

6L+6T+6P=18 Hours

UNIT-1

Importance and objectives of farm mechanization in Indian Agriculture: benefits of agricultural mechanization, input savings, increase in efficiency, social benefits, size of land holding in India, mechanization, power sources and productivity, estimates of investments by farmers in farm machinery, research and development, production and extension system.

UNIT-2

Quality of farm machinery and training, adoption and impact of agricultural mechanization and future strategies for mechanization. Estimation of operating cost of tractors, estimation of fuel consumption for full and pat loads and farm machinery.

PRACTICES:

1. Study of latest development of different agricultural equipment and implements in India and other developing countries.
2. Experimental determination of field capacity of different farm machines.
3. Estimation of cost to complete the unit area by using primary tillage implement

4. Estimation of field capacity and field efficiency of secondary tillage equipments

MODULE-2

18L+18T+18P=54 Hours

UNIT-1

Management and performance of power, operator, labour, economic performance of machinery, field capacity, field efficiency and factors affecting field efficiency.

UNIT-2

Tractor power performance in terms of PTO, drawbar and fuel consumption. Power requirement problems to PTO, DBHP. Selection of farm machinery, size selection, timeliness of operation, optimum width and problem related to its power selection; selecting proper power level and problem related to it.

UNIT-3

Reliability of agricultural machinery. Replacement of farm machinery and inventory control of spare-parts. Systems approach to farm machinery management and application of programming techniques to farm machinery selection and scheduling.

PRACTICES:

1. Size selection of agricultural machinery based on the size of power unit.
2. Study and selection of suitable farm machinery in relation to crop yield.
3. Determination of optimum machinery system for field crop and machine constraints.
4. Measurement of tractor PTO speed and specific fuel consumption

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1.	Selection of appropriate machinery and power source for their effective utilization on the mechanized farm	Apply	1	2,3,5,7,8,11
2.	Develop an optimum farm machinery management practices for the farm	Create	1	1,3,4,6,8,10,11,12

3.	Develop decision supporting systems for tractor and farm machinery	Create	2	1,3,4,6,8,10,11,12
4.	Apply the computer and internet for the management of farm resources and outputs	Apply	2	1,3,5,6,7,8,9,10
5.	Apply programming techniques to farm machinery selection and scheduling	Apply	2	1,3,5,6,7,8,9,10,11

Mapping of Sustainable Development Goals (SDGs) and Indian Knowledge System (IKS)

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 2 – Zero Hunger	Ancient Indian farming emphasized timely operations (Ritu-based farming, Panchang-guided sowing).
SDG 7 – Affordable & Clean Energy	Traditional energy-efficient practices like bullock power, Persian wheels, and bio-energy.
SDG 8 – Decent Work & Economic Growth	Cooperative labour systems (Kudimaramath, Balutedari) in Indian villages ensured equitable work distribution.
SDG 9 – Industry, Innovation & Infrastructure	Indigenous innovations in irrigation devices, ploughs, and storage structures are precursors to modern machinery.
SDG 12 – Responsible Consumption & Production	Ancient storage systems (granaries, seed preservation in earthen pots) minimized waste and promoted sustainability.
SDG 13 – Climate Action	Traditional eco-friendly farming systems (composting, natural fertilizers) ensured low carbon footprint.
SDG 15 – Life on Land	Indian knowledge values “Bhumi” (soil) as sacred, stressing balance and protection of land resources.

TEXT BOOKS:

1. Culpin, C, Profitable farm mechanization, Lock Wood & Sons, London, 2006.
2. Hunt, D, Farm Power and Machinery Management, Iowa State University Press, USA, 1999.
3. Singh, S. And Verma, S. R. Farm Machinery Maintenance and Management. DIPA, ICAR, KAB-I, New Delhi, 2001

REFERENCE BOOKS:

1. Carveille, L. A. (1999). Selecting farm machinery. Louisiana Cooperative Extn.

Services publication.

2. Watters, W. K. (2001) Farm Machinery Management guide. Pennsylvania Agri.Extn. Services Spl. Circular No 2002.
3. F A O (2018). Agricultural Engineering in develop: selection of mechanization inputs, F A O, Agri. Service Bulletin.

SKILLS:

- Matching of tractor and machinery
- Application of programming techniques to farm machinery selection and scheduling



Image source link: https://www.upaharbazar.com/wp-content/uploads/2023/08/farm-power-and-machinery-management.jpg

Image file name: Farm Power and Machinery Management

22FMB104 - DESIGN OF PLANT PROTECTION AND HARVESTING EQUIPMENT

Hours per week:

L	T	P	C
2	2	2	**4**

PREREQUISITE KNOWLEDGE: Fundamental knowledge about different types of sprayer, dusters, working principles of all types of sprayer and selection of suitable sprayer for specific use.

COURSE DESCRIPTION AND OBJECTIVES:

To learn about farm machinery design principles, design of components of sprayers and dusters, design parameters of a fertilizer distributor and their working, design of harvesting equipment's and safety devices for tractor and farm implements.

MODULE-1

UNIT-1 **6L+6T+6P=18 Hours**

Fundamentals and economic considerations for design consideration for development of plant protection and harvesting machinery.

UNIT-2

Factors affecting the farm machinery design. Introduction of Machines for fertilizer application and discs type broadcasters.

PRACTICES:

1. Statement and formulation of design problems.
2. Design of manually and power operated plant protection equipment
3. Calibration, field testing and handling techniques of tall tree sprayer
4. Design of sprayer components – pumps, pressure vessel, nozzle and materials of construction.

MODULE-2

18L+18T+18P=54 Hours

UNIT-1

Design of pumps and atomizing devices for sprayers. Fertilizer handling equipment and

their design consideration. Design of centrifugal broadcaster. Design of duster.

UNIT-2

Design consideration of threshing and harvesting equipment in reference to types of cylinder, design of threshing cylinder and safety measures. Forces acting on a cutter bar of a reaper.

UNIT-3

Safety devices for harvesting and threshing machinery. Manufacturing limits and fits in harvesting and threshing machinery. Material bill and construction cost in harvesting and threshing machinery project design.

PRACTICES:

1.Design of cylinder for a multi-crop thresher.

2.To compare design criteria for different harvesting machines.

3.To compare design considerations in different types of power threshers.

4.Study of various safety devices for threshers and harvesters

COURSEOUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Application of design principles for design different types of sprayer	Apply	1	1,5,6,8
2	Design of centrifugal broad caster	Create	1	3,4,5,8
3	Analysis of different design consideration of threshing and harvesting equipment	Analyse	2	2,4,5,6,7,11
4	Analysis of Safety devices for tractors and farm implements	Analyse	2	2,4,5,6,9
5	Application of reliability criteria in design of farm machinery	Apply	2	1,5,6,8,11,12

Mapping of Sustainable Development Goals (SDGs) and Indian Knowledge System (IKS)

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 2 – Zero Hunger	Traditional crop protection methods (ash dusting, neem extracts, manual threshing) ensured food security.
SDG 3 – Good Health & Well-Being	Ayurveda-based natural pesticides (Neem, Tulsi, Cow urine preparations) highlight health-centric protection.
SDG 7 – Affordable & Clean Energy	Indigenous use of manual and animal-powered devices for spraying and threshing reflects low-energy solutions.
SDG 8 – Decent Work & Economic Growth	Traditional cooperative work systems (e.g., *Polygars*, *Kudimaramath*) highlight community-based agricultural efficiency.
SDG 9 – Industry, Innovation & Infrastructure	Rural artisans historically innovated low-cost tools (sickles, hand threshers) forming the base for modern designs.
SDG 12 – Responsible Consumption & Production	Ancient emphasis on durability and repairability of farm tools ensured sustainable consumption.
SDG 13 – Climate Action	Traditional organic farming minimized chemical use, showing climate-resilient practices.
SDG 15 – Life on Land	Indian farming philosophy (*Bhumi Sukta* in Rigveda) treats land and crops as sacred resources to be preserved.

TEXT BOOKS:

1. Sharma, D. N. And Mukesh S. Farm Machinery Design. Principles and problems. Jain Brothers, East Park Road, New Delhi, 2010.
2. Kepner R. A., Bainer Ray and Barger E. L. Principle of Farm Machinery, AVI Pub., 1 an 2005.
3. Varshney A.C. Data Book for Agricultural Machinery Design, Central Institute of Agricultural Engineering, 2004.
4. Kurtz. G., Thompson, L. and P. Claar. Design of Agricultural Machines, John Willey and sons, 1994.

REFERENCE BOOKS:

1. Ralph Al cock. Tractor Implement System. AVI Pub. 1986.
2. Bernacki, H. Kanafozski, O and T. Karvowski. Agriculture machines: Theory and Construction. Vol.I and II, translated and published by US Deptt. Of Agriculture,

1996.

3. Bosoi, E. S. Vermiaev, O V, Smirnov, I. I. And Sultan–Shakh, E. G. theory, construction and calculation of agriculture machines, A. A Balkema Pub., Rotterdam, 1998.
4. Gyachev, L. V. Theory of surfaces of plow bottoms, A. A Balkema Pub. Rotterdam, 1997.
5. Nartov, P. S. Disc Soil Working implements, A. A. Balkema Pub. Rotterdam, 1996.

SKILLS:

- Design Plant protection equipment
- Design harvesting equipment
- Design threshing equipment



Image source link: https://www.deere.ca/assets/images/region-4/products/harvesting/tseries-combine-r2C001197-1920x1080.jpg

Image file name: Design of Plant Protection And Harvesting Equipment

22FMB105 - TESTING AND EVALUATION OF TRACTORS AND FARM EQUIPMENT

Hours per week:

L	T	P	C
3	0	2	**4**

PREREQUISITE KNOWLEDGE:

Fundamental knowledge of different types of tractor systems, adjustments of farm machinery, working of combine harvester and threshers.

COURSE DESCRIPTION AND OBJECTIVES:

To Gain knowledge about testing of agricultural machines and testing of farm tractor, tractor test code BIS: ISO: OECD and Nebraska testing institute

MODULE-1

UNIT-1 **18L+0T+12P= 30 Hours**

Importance and significance of testing and types of tests needed for testing of tractor, application of measurement techniques to testing procedures, measurement of power

UNIT-2

Testing of agricultural machines and procedures for evaluation of M.B. Plough, Disc Plough, Rotavator, Cultivator, Disc Harrow,

PRACTICES:

1. Testing of agricultural machines, Mould Board plough and Disc Plough following test codes.
2. Performance evaluation of Mould Board plough and Harrows.
3. Performance evaluation of Seed cum fertilizer/Planters drill
4. Performance evaluation of Weeders

MODULE-2

27L+0T+18P=45 Hours

UNIT-1

Testing of agricultural machines and procedures for evaluation of Seed cum fertilizer drill & planters, manual and power operated weeders.

UNIT-2

Testing of agricultural machines and procedures for evaluation of Plant protection machines, Reaper, Thresher and Chaff cutter, Combine harvesters.

UNIT-3

Testing of farm tractor – Tractor test codes: BIS: ISO: OECD and Nebraska testing institute.

PRACTICES:

1. Performance evaluation of plant protection equipments.
2. Performance evaluation of reapers.
3. Testing and performance of power thresher.
4. Testing of tractor as per BIS.

COURSEOUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	To apply with different instruments used in testing of agricultural machinery.	Apply	1	1,6,7,8
2	To analyse the standard testing procedures and rules.	Analyse	1	2,4,7,10
3	To analyse different test codes of ISO, RNAM, ASTM, ASABE etc.	Analyse	2	1, 2,9,12
4	Carry out performance evaluation of different agricultural implements	Evaluate	2	1,2,4,5,6,8,9,10,12

Mapping of Sustainable Development Goals (SDGs) and Indian Knowledge System (IKS)

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 2 – Zero Hunger	Traditional validation of tools (trial methods for ploughs and sickles) ensured dependable food production.
SDG 7 – Affordable & Clean Energy	Indigenous reliance on renewable animal power and bio-energy highlights sustainable energy practices.
SDG 8 – Decent Work & Economic Growth	Rural craftsmanship and local innovations created job opportunities while supporting farm productivity.
SDG 9 – Industry, Innovation & Infrastructure	Indian blacksmithing and tool-making traditions served as early industry benchmarks in rural infrastructure.
SDG 12 – Responsible Consumption & Production	Ancient repair-oriented practices (sharpening, reforging, reuse of parts) minimized wastage.
SDG 13 – Climate Action	Organic and eco-friendly practices traditionally minimized environmental impact.
SDG 15 – Life on Land	Vedic emphasis on *Bhumi* (soil as sacred) highlights harmony with land and biodiversity.

REFERENCE BOOKS:

1. Anonymous.1993. RNAM Test Code & Procedures for Farm Machinery. Technical Series 12
2. Barger E L, Liljedahl J B & McKibben E C.1997. Tractors and their PowerUnits. Wiley Eastern.
3. Indian Standard Codes for Agril. Implements. Published by ISl, New Delhi.
4. Inns F M.1996. Selection, Testing and Evaluation of Agricultural Machines and Equipment. F A O Service Bull. No. 115.
5. Lal R & Dutta Pc. 1979. Agricultural Engineering (through solve examples). Saroj Parkashan,
6. Metha M L, Verma S R, Mishra S K & Sharma V K. 1995. Testing and Evaluation of Agricultural Machinery. National Agricultural Technology Information Centre, Ludhiana.
7. Nebraska Tractor Test Code for Testing Tractor, Nebraska, USA.
8. Smith DW, Sims BG & O'Neill D H. 2001. Testing and Evaluation of Agricultural Machinery and Equipment - Principle and Practice. FAO Agricultural Services Bull.110.

SKILLS:

- Testing of tillage equipment
- Testing of harvesting and threshing machinery
- Testing of tractor as per guidelines



Image source link: https://kj1bcdn.b-cdn.net/media/83780/tractors.jpg

Image file name: Testing and Evaluation of Tractors and Farm Equipment

ELECTIVE COURSES

22FMB801 - ERGONOMICS AND SAFETY IN FARM OPERATIONS

Hours per week:

L	T	P	C
2	0	2	**3**

PREREQUISITE KNOWLEDGE:

Acquaintance of knowledge about mental and physical stress as well as human being comfortable zone

COURSE DESCRIPTION AND OBJECTIVES:

To acquire the knowledge about human metabolism, Physical, mental stress, Muscular work efficiency, Effect of vibration on man and Human factors in tractor seating.

MODULE-1

12L+0T+12P=24 Hours

UNIT-1

Human factors in system development, importance, objectives, scope. The operator-machine-environment system approach, Human being in man-made world. Importance of ergonomics, ergonomic goals. Human tracking and human metabolism.

UNIT-2

Physiological parameter. Physical and mental stress, their nature and measurement techniques. Muscular work efficiency, fatigue and rest pauses.

PRACTICES:

1. Measurement of body dimensions of agricultural workers and relationship between them.
2. Calibration of human subject on bicycle ergo meter for its energy output and physiological parameters like heartrate, oxygen consumption rate under laboratory conditions.
3. Calibration of human subject on treadmill for its energy output and physiological

parameters like heart rate and oxygen consumption rate under laboratory conditions.

4. Evaluation of heat stress while calibrating the subject.

MODULE-2

18L+0T+18P=36 Hours

UNIT-1

Human factors in tractor seating, comfort and entry system. Control, shape, colour - coding, appearance, dial and indicators. Anthropometry and its application.

UNIT-2

Heat and cold stress. Measurement of energy; direct and indirect methods. Calibration of subjects. Physical load and its assessment, scaling of load, modes of work importance of postures for safety consideration in design of farm machinery. Safety consideration in farm operation.

UNIT-3

Effect of vibration on man, vibration measurement and vibration control. Effect of illumination, atmosphere, visibility, noise, dust concentration and toxicity on human being. Application of time motion study in agricultural operations. Modern technology used for comfort in driving places. BIS codes for tractor and machine safety.

PRACTICES:

1. Determination of muscular fatigue for selected agricultural tasks.
2. Study of noise levels for engine/tractor.
3. Study of vibrations in farm tractors and agricultural machines.
4. Study of standard time for selected farm operations

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Design of different Ergonomic models	Create	1	3,4,6,8,10,11,12
2	Analysis of various mental and physical	Analyse	1	1,2,4,6,8,10,11

	stress measurement techniques			
3	Application of human factors in tractor seating	Apply	1	1,3,5,6,7,8,9,10
4	Analysis of different safety factors in farm operations	Analyse	2	1,2,4,6,8,10,11
5	Estimation of vibration effects on human body (Operator)	Evaluate	2	1,2,4,5,6,8,9,10,12

Mapping of Sustainable Development Goals (SDGs) and Indian Knowledge System (IKS)

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 3 – Good Health & Well-Being	Ayurveda and Yoga emphasize physical & mental balance, rest–work cycles, and breathing control to improve human performance.
SDG 4 – Quality Education	Ancient *Shilpa Shastra* and *Ayurvedic ergonomics* stressed proportion, balance, and human-centric design.
SDG 8 – Decent Work & Economic Growth	Traditional cooperative work culture (*Kudimaramath*, *Shramdaan*) emphasized worker well-being and safety.
SDG 9 – Industry, Innovation & Infrastructure	Indigenous craftsmanship (blacksmiths, carpenters) focused on tool design that matched human posture and comfort.
SDG 12 – Responsible Consumption & Production	Traditional repair–reuse approach in Indian farming tools emphasized long life and minimal wastage.
SDG 13 – Climate Action	Traditional low-energy human-powered and animal-powered systems demonstrated sustainable energy use.
SDG 15 – Life on Land	Indian farming philosophy emphasized harmony between humans, animals, and land (*Bhumi Sukta*, Vedic farming).

TEXT BOOKS:

1. Astrant, P.O. and K. Rodhal. A textbook of work physiology McGraw Hill Book Co., New York, 4thedition, 2022.
2. Cormic Mc ,E.J., Human Factors in Engineering Design, Tata McGrew Hill Pub., Co., New Delhi,7th edition, 2019.

REFERENCE BOOKS:

1. Bridger R S, Introduction to Ergonomics. McGraw Hill, 4th edition, 2019.
2. IS12239.Tractors and Machinery for Agriculture and Forestry: Technical Means for Ensuring Safety.1999.

SKILLS:

- Develop ergonomic models to test human metabolism
- Estimate the agricultural workers mental and physical stress
- Apply time motion study in agricultural operations



Image source link: https://gpcah.public-health.uiowa.edu/wp-content/uploads/2017/02/Whole-Body-Vibration.jpg

Image file name: Ergonomics and Safety in Farm Operation

22FMB802 - APPLIED INSTRUMENTATION IN FARM MACHINERY AND STRESS ANALYSIS

Hours per week:

L	T	P	C
2	0	2	**3**

PREREQUISITE KNOWLEDGE:

Basic knowledge about stress, strain, calorific value of a substance and use.

COURSE DESCRIPTION AND OBJECTIVES:

To get the knowledge about Strain, stress, measuring devices for displacement, active and passive transducers, calorific value measuring devices for solid, liquid, gaseous and data acquisition system.

MODULE-1

12L+0T+12P=24 Hours

UNIT-1

Measurement - methods - Instrument and classification of instruments-static and dynamic characteristics of instrument. General measurement system - Functional elements of a measurement system - Strain and stress: Strain relationship, strain-gauges; Mechanical, optical, electrical acoustical and pneumatic etc., and their use.

UNIT-2

Various methods of determining strain/stress experimentally. Measuring devices for displacement (linear and rotational), basic methods of pressure measurement, basic methods of force measurement, torque measurement on rotating shaft and shaft power.

PRACTICES:

1. Bonding of gauge, lead wire installation.
2. Testing of Gauge.
3. Study of temperature compensating gauge and their circuits.
4. Study of characteristics of equipment needed for static and dynamics train measurements.

MODULE-2

18L+0T+18P=36 Hours

UNIT-1

Strain-gauges: Types and their application in two- dimensional and three-dimensional force measurement. Introduction to functional elements of instruments. Active and passive transducers, analog and digital modes.

UNIT-2

Static and dynamic characteristics of instruments. Devices for measurement of temperature, relative humidity, pressure, flow, sound and vibration. Recording devices and their types.

UNIT-3

Measuring instruments for calorific value of solid, liquid and gaseous fuels. Data acquisition system, microcomputers, data storage and their applications.

PRACTICES:

1. Calibration of instruments.
2. Measurement of velocity, force, torque and shaft power.
3. Measurement of sound and vibration.
4. Study of modern trends in micro computer and data storage.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Estimation of stress and strain for different materials	Evaluate	1	1,2,4,5,6,8,9,10,12

2	Application of different devices to measure the linear and rotational displacement	Apply	1	1,3,5,6,7,8,9,10
3	Analyse the two and three-dimensional force measurement.	Analyse	2	1,2,4,6,8,10,11
4	Application of active and passive transducers.	Apply	2	1,3,5,6,7,8,9,10,12
5	Analysis of data acquisition system and microcomputers	Analyse	2	1,2,4,5,6,8,10,11

Mapping of Sustainable Development Goals (SDGs) and Indian Knowledge System (IKS)

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 4 – Quality Education	Ancient Indian texts (e.g., *Sulba Sutras*) detailed precise measurement systems in construction and engineering.
SDG 7 – Affordable & Clean Energy	Traditional energy assessments (efficiency of water wheels, bullock carts) ensured minimal energy wastage.
SDG 8 – Decent Work & Economic Growth	Ancient craftsmanship (blacksmiths, architects) relied on precise measurements for productivity and safety.
SDG 9 – Industry, Innovation & Infrastructure	Indigenous innovations (astrolabe, gnomon, water clocks) show India's legacy in measurement science.
SDG 12 – Responsible Consumption & Production	Traditional practices emphasized *"Mita Upayoga"* (measured/limited use of resources).
SDG 13 – Climate Action	Ancient farming and energy use emphasized eco-balance and sustainability.
SDG 15 – Life on Land	Vedic farming principles considered land (*Bhumi*) as sacred, promoting careful use and monitoring.

TEXT BOOKS:

1. Dove R. C. and Adams P. H. Experimental Stress Analysis (McGraw Hill, 1997)
2. Dally J.W. and Riley W.F. Experimental Stress Analysis (McGraw-Hill Inc., New York, 1998)
3. Srinath, L.S. and Raghavan M.R. Experimental Stress Analysis (Tata McGraw-Hill, 1998).

REFERENCE BOOKS:

1. Freddi A. Olmi G. and Cristofolini L. Experimental Stress Analysis for Materials and Structures (Springer, Switzerland, 2015)

2. Sharpe W.N. Handbook of Experimental Solid Mechanics (Springer, 2008)
3. Kandil F.A., Lord J.D., Fry A.T. and Grant P.V. A review of residual stress measurement methods A guide to technique selection (NPL Report MATC(A) 04, February 2001, NPL
4. Kamal S.M. Borsaikia A. and Dixit U.S. Experimental assessment of residual stresses induced by the thermal autofrettage of thick-walled cylinders, Journal of Strain Analysis, Vol. 51(2), pp 144−160, 2016.

SKILLS:

- Develop a strain gauges to measure the stress and strain of different materials
- Estimate the different parameters of material and convert in to convenient form by using transducers
- Test data acquisition system to find out the different characteristics of testing system in different form.



Image source link:

https://th.bing.com/th/id/R.b29b1ea44d0e60e7a132e35ec155fc96?rik=HKz4ULE%2f2XXTtw&riu=http%3a%2f%2fagreng.agr.uth.gr%2fsystem%2ffiles%2fimagepicker%2f18%2fMonosem.jpg&ehk=39rsm%2bV1SQkzToxvD9VAUT1qAHVBTY2nXWCDHYSK%2b6E%3d&risl=&pid=ImgRaw&r=0

Image file name: Applied Instrumentation in Farm Machinery and Stress Analysis

22FMB803 - TRACTOR DESIGN

Hours per week:

L	T	P	C
2	0	2	**3**

PREREQUISITE KNOWLEDGE: Basic knowledge about different systems of tractor as well as working and need of all the individual components of tractor.

COURSE DESCRIPTION AND OBJECTIVES:

To acquire the knowledge about technical specifications of all the components of different systems of tractor from I C engine to power take off of a tractor.

MODULE-1

12L+0T+12P=24 Hours

UNIT-1

Introduction about design and development of Agricultural tractor, study of specific design features of tractor engines and their selection.

UNIT-2

Design of IC engine components: piston, piston pin and rings, connecting rod, crankshaft, cam shaft, valves.

PRACTICES:

1. Design of various IC engine components.
2. Experimental determination of Centre of gravity.
3. Performance evaluation of response time of automatic: depth control.
4. Performance evaluation of response time of automatic: position control

MODULE-2

18L+0T+18P=34 Hours

UNIT-1

Design of various components of three-point tractor hitch system geometry, kinematics and force analysis of hitch system geometry, hydraulic system design considerations,

design of main components of hydraulic system, tractor steering and suspension systems.

UNIT-2

Design of IC engine components: Engine block, cylinder and cylinder liners, cylinder head studs and valve spring, fuel injection systems and types, merits and demerits of each type

UNIT-3

Design of supercharging–general, turbo charging units and system. Transmission system: Types, transmission line, features of gear boxes used for farm tractor. Differentials, final drives and axles, power take off shaft.

PRACTICES:

1. Automatic draft control on a farm tractor.
2. Study of various hydraulic components in relation to design of hydraulic system of a farm tractor.
3. Study of performance evaluation of different transmission system.
4. Problems showing utilisation of hydraulics in farm machines.

COURSEOUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Analyse the mechanical specification of a tractor	Analyse	1	1,2,4,6,8,10,11
2	Design of piston of I C engine	Create	1	3,4,6,8,10,11,12
3	Analysis of importance of I C engine components	Analyse	2	1,2,4,6,8,10,11
4	Application of super charger and turbocharger in tractors	Apply	2	1,3,5,6,7,8,9,10,12
5	Analyse the features of gear boxes used for farm tractor	Analyse	2	1,2,4,6,8,10,11,12

Mapping of Sustainable Development Goals (SDGs) and Indian Knowledge System (IKS)

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 4 – Quality Education	Ancient *Shilpa Shastra* and *Yantra Vidya* texts described engineering principles, fostering knowledge transfer and technical education.
SDG 7 – Affordable & Clean Energy	Traditional devices like *Persian wheels*, bullock-drawn ploughs, and water mills used renewable energy efficiently.
SDG 8 – Decent Work & Economic Growth	Indigenous draught animal technologies promoted labor efficiency and sustained rural economies.
SDG 9 – Industry, Innovation & Infrastructure	Ancient innovations in *Ratha (chariot)* construction, irrigation systems, and mechanical automata reflected advanced indigenous engineering.
SDG 12 – Responsible Consumption & Production	*Arthashastra* and *Vriksha Ayurveda* advocated sustainable use of resources and minimized wastage in production.
SDG 13 – Climate Action	Ancient Indian farming methods promoted low-carbon practices such as mixed cropping and natural soil fertility management.
SDG 15 – Life on Land	Vedic literature (e.g., *Bhumi Sukta* in Atharva Veda) emphasized harmony with soil and sustainable agriculture practices.

TEXT BOOKS:

1. Kolchin, A. and Dominov, V. Design of Automotive Engines, Mir Publishers, Moscow, 2004.
2. Liljidahl, B.J. Turnquist, P.K. Smith, W.D. and Hoki, Makato. Tractor and their powerunits, Forth Edition, Avi Publications, New York, 2009.

REFERENCE BOOKS:

1. Litcy,C.V.,Internal Combustion Engines, McGrawHill Pub.,NewYork,2018.
2. Maleev,V.L., Internal CombustionEngines,McGrawHillPub.,NewYork, 2020.

SKILLS:

- Testing of different output powers of a tractor
- Develop a suitable prime mower for small land holders
- Estimate and match the suitable attachment as per the developed tractor power



Image source link: https://static.country-guide.ca/wp-content/uploads/2021/02/17121059/prototype.jpg

Image file name: Tractor Design

22FMB804 - POWER HYDRAULICS

Hours per week:

L	T	P	C
2	0	2	**3**

PREREQUISITE KNOWLEDGE:

Application of hydraulic system in a tractor and basic knowledge about working principle of pumps, cylinder and piston

COURSE DESCRIPTION AND OBJECTIVES:

To get the knowledge about principle of hydraulic system, hydraulic pumps, calculation of hydraulic force equipment, different types of hydraulic valves, power steering, power brakes and tractor hydraulics.

MODULE-1

12L+0T+12P=24 Hours

UNIT-1

Hydraulic principles: Hydraulic pumps, types, circuits and drives. Hydraulic valves- pressure control valves, flow control valves, directional control valves, cartridge valves and strength calculations.

UNIT-2

Hydraulic cylinders – displacement, single and double acting, acceleration and deceleration of cylinder loads, cylinder mounting and strength calculation.

PRACTICES:

1. Study of various hydraulic pumps.
2. Study of hydraulic valves.
3. Study of directional control valves.
4. Study of hydraulic cylinder piston arrangements.

MODULE-2

18L+0T+18P=34 Hours

UNIT-1

Semi-rotary actuator – type and control. Hydraulic motors and circuit. Hydraulic fluid – properties and future development.

UNIT-2

Fluid contamination – types and control. Filter construction and filtration technology. Leakage control in hydraulic system.

UNIT-3

Control system – servo control, valve servo system, pump servo system and proportional valves. Use of hydraulic and pneumatic drives in agricultural systems: power steering, power brakes and tractor hydraulics.

PRACTICES:

1. Study of engineering properties of hydraulic fluids.
2. Study of hydraulic system of tractor.
3. Study of hydraulic steering system.
4. Study of problem related to hydraulic control system.
5. Study of hydraulic motors.

COURSEOUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Analyse working of different components of hydraulic system	Analyse	1	1,2,4,6,8,10,11
2	Estimation of loads and strength of hydraulic components	Evaluate	1	1,2,4,5,6,8,9,10
3	Analyse the properties of hydraulic fluids	Analyse	2	1,2,4,5,6,8,10,11
4	Application of hydraulic principle in power steering, power brakes of a tractor	Apply	2	1,3,5,6,7,8,9,10,12
5	Analyse the use of hydraulic and pneumatic drives in agricultural systems	Analyse	2	1,2,4,6,8,10,11,12

Mapping of Sustainable Development Goals (SDGs) and Indian Knowledge System (IKS)

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 4 – Quality Education	Ancient treatises like *Samarangana Sutradhara* and *Yantra Sarvasva* documented hydraulic and pneumatic devices for education in mechanical systems.
SDG 7 – Affordable & Clean Energy	Traditional Indian water-lifting devices (Persian wheel, *shaduf*, step-wells) used fluid principles efficiently with renewable energy.
SDG 8 – Decent Work & Economic Growth	Indigenous farming tools reduced labor intensity and supported sustainable livelihoods.
SDG 9 – Industry, Innovation & Infrastructure	Ancient hydraulic innovations (irrigation canals, reservoirs, tank systems in South India) were engineering marvels supporting agriculture.
SDG 12 – Responsible Consumption & Production	IKS emphasizes *aparigraha* (minimalism) and efficient use of natural resources in agriculture and engineering.
SDG 13 – Climate Action	Ancient sustainable hydraulic systems (like *Phad irrigation* in Maharashtra) were designed with low environmental impact.
SDG 15 – Life on Land	*Vriksha Ayurveda* and *Bhumi Sukta* emphasized conservation of land, soil fertility, and sustainable farming.

TEXT BOOKS:

1. Liljedahl, B. J. Turanquist, P. K., Smith W. D. and Hoki Vaketo. Tractor and Their Power Units. AG publication, Fourth Edition, New York, 2009.
2. Michael, J. P. and John, G. A. Power Hydraulics. Prenlice Hall, NewYork, 2011

REFERENCE BOOKS:

1. Hydraulics, Fundamentals of Service. John Deere Service Publications, 2001. John Deere Road, Moline, 61265.

SKILLS:

- Testing of different hydraulic pumps
- Develop a suitable hydraulic system to lift the weights
- Estimate the power calculations

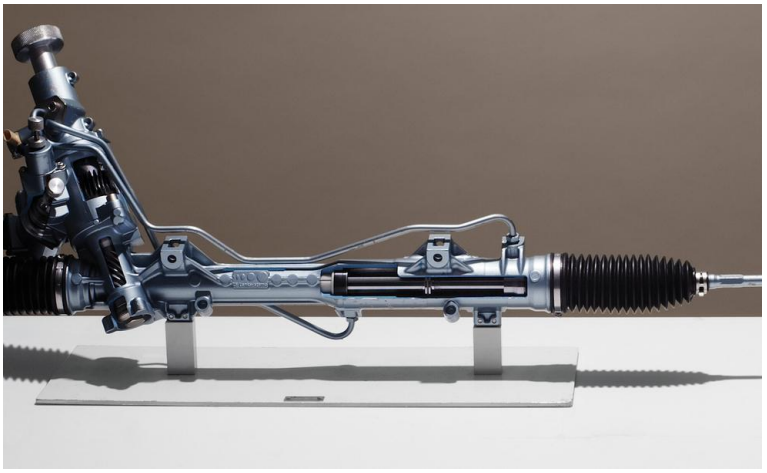


Image source link: https://static.pakwheels.com/2016/10/hydraulic-power-steering-system.jpg

Image file name: Power Hydraulics

22FMB805 - LAND GRADING AND EARTH MOVING MACHINERY

Hours per week:

L	T	P	C
2	0	2	**3**

PREREQUISITE KNOWLEDGE: Fundamental knowledge about criteria and methods followed for land levelling and basic knowledge about various earth moving equipments.

COURSE DESCRIPTION AND OBJECTIVES:

Students will be able to study the land levelling: Criteria and methods; Plane, profile & plan inspection; Earth work calculations; types, construction, capacity and working of the machines like Bulldozer Scraper; Grader; Shovel; Dragline, clamshell, trenching machine & compactors, Drilling and drilling tools; basting and types of explosive & stemming; Transportation and handling of explosive; Application of CPM; Safety engineering for construction.

MODULE-1

12L+0T+12P=24 Hours

UNIT-1: LAND LEVELLING

criteria for land levelling, levelling layout of field for irrigation and drainage systems, survey and stacking**,** land levelling methods, contour bench levelling, construction of contour benches, earthwork quantities computation.

UNIT-2: EARTH WORK

Types, construction, capacity and working of the following machines: bulldozer, scraper, grader, small implements for levelling and grading

PRACTICES:

1. Land levelling by various methods.
2. Preparation of contour map for land levelling.
3. Study and operation of bulldozer.
4. Study and operation of the Power shovel.

5. Study the components of Dragline.

MODULE-2

18L+0T+18P=34 Hours

UNIT 1: DRILLING AND BLASTING

Air operated drilling tools: jack hammer, drifter, wagon drill. Selection of drilling equipment, types of explosive and stemming, transportation and handling of explosive; blasting caps and storage.

UNIT 2: EARTH WORK:

Excavation equipment, excavator loaders, shovel, dragline, clamshell, trenching machine & compactors. earth work calculations.

UNIT 2: MACHINE JOB

Job planning and management; Critical path management (CPM), Application and advantages of CPM, Program evaluation review technique (PERT), procedure of PERT, Safety engineering for construction

PRACTICES:

1. Practice of drilling a hole with a pneumatic drill
2. Practice of putting explosive in the hole.
3. Blasting practice in hard soils.
4. Blasting practice in hard soils with the help of explosives.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Application of different methods for land levelling	Apply	1	1,3,5,6,7,8,9,10
2	Analysis of working different earth moving machines	Analyse	1	1,2,4,6,8,10,11
3	Application and transportation of	Apply	2	1,3,5,6,7,8,9,10,11

	explosive material			
4	Analysis of Job planning and management	Analyse	2	1,2,4,5,6,8,10,11
5	Application of CPM in earth moving	Apply	2	1,3,5,6,7,8,10,11,12

Mapping of Sustainable Development Goals (SDGs) and Indian Knowledge System (IKS)

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 2 – Zero Hunger	Ancient *Krishi-Parashara* and *Vriksha Ayurveda* emphasized proper field layout and water management for higher yields.
SDG 6 – Clean Water & Sanitation	Traditional water management practices like *Ahar-Pyne* (Bihar) and *Johads* (Rajasthan) optimized field water use.
SDG 7 – Affordable & Clean Energy	Indigenous low-energy soil and water conservation practices relied on manpower, animals, and renewable energy.
SDG 8 – Decent Work & Economic Growth	Local community-driven land development practices historically provided sustainable livelihoods.
SDG 9 – Industry, Innovation & Infrastructure	Ancient Indian civil engineering marvels (like Kallanai Dam, Grand Anicut – Tamil Nadu) show innovation in earthwork and hydraulics.
SDG 11 – Sustainable Cities & Communities	IKS reflects eco-friendly planning in stepwells (*baolis*), fortifications, and irrigation systems with community management.
SDG 12 – Responsible Consumption & Production	Traditional practices emphasized balance (*samyama*) and avoiding excess exploitation of land and materials.
SDG 13 – Climate Action	Ancient contour bunding and terracing methods in Himalayan & tribal regions were climate-resilient practices.
SDG 15 – Life on Land	Ancient land-use practices integrated forests, grazing, and agriculture, maintaining biodiversity.

TEXT BOOKS:

1. Michael, A. M. Irrigation: Theory and Practice. Vikas Publishing House Pvt.Ltd., New Delhi,2007.
2. Nichols, H. L. Moving the Earth, Second Edition, Golotia Publishing house, New Delhi-1, 1992.
3. Peurifoy, R. L. Construction, Planning Equipment and Methods, Third Edition, McGrew Hill International Book Co., 1999.

SKILLS:

- Estimate the capacity and work output of bulldozer
- Able to select the suitable drilling machine for specific work
- Proper handling of blasting materials



Image source link: https://c8.alamy.com/comp/2GG2JY1/bulldozer-excavator-and-soil-compactor-on-road-work-earth-moving-heavy-equipment-and-construction-machinery-during-land-clearing-grading-pool-exca-2GG2JY1.jpg

Image file name: Land Grading and Earth Moving Machinery

22FMB806 - HORTICULTURE AND FORESTRY EQUIPMENT

Hours per week:

L	T	P	C
2	0	2	**3**

PREREQUISITE KNOWLEDGE: Fundamental knowledge about farm mechanization and crop protection equipment

COURSE DESCRIPTION AND OBJECTIVES:

To introduce the students with different types of mechanical aids to be used for plantation crops from planting to harvesting and to transport the forest products. Also, students will study the cost estimation of different horticultural operations using various equipment and different management techniques to minimize the cost of operation.

MODULE-1

UNIT-1 **12L+0T+12P=24 Hours**

Mechanization for crops plantation, forestry operations, forestry machines and equipment. Machinery for land preparation and forest establishment. The operation and application of forest machinery.

UNIT-2

Machines for posthole digging, seeding, planting, plant protection, circular saw, shearing blades, slasher, winches, beams, ripper, bunches, tree felling. Forest cleaning and reclamation, logging, stump blasting. Fire control, fire line and their maintenance.

PRACTICES:

1. Study of different hand tools for forestry.
2. Study of different equipment for forestry.
3. Identification of operations in forestry for which new tools need to be designed and developed.
4. Field testing of different equipment used for horticultu

MODULE-2

18L+0T+18P=34 Hours

UNIT-1

Fundamentals of horticultural operations-land preparation, sowing, planting, transplanting, plant propagation and harvesting. Fundamentals of tools and equipment used for land preparation, nursery bed preparation, bed making/digging, sowing of seeds of fruits, vegetables and flowers, raising of nursery

UNIT-2

Planting/transplanting of seedling, plant propagation-pruning, budding, grafting, cutting etc. Plant protection and harvesting equipment.

UNIT-3

Development of resources, ditching and dewatering of ponds. Use of dozers, wheel loaders, motor graders, scrappers, knock down beams and ripper, forest transport machinery. Cost estimation of forestry operations, management techniques to minimize cost of operation.

PRACTICES:

1. Estimation of field capacity for land preparation
2. Study of different equipment for horticulture and estimate the field capacity
3. Identification of operations in horticulture for which new tools need to be designed and developed.
4. Estimation of cost of forestry equipment and suggestion to minimize the operating cost.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1.	Educate about importance of trees in agriculture, forest regeneration, forest	Understanding	1	1,2,7,11

	mensuration, agro-forest			
2.	Analyse various factors affecting standing trees in forest and plantations, forest management, forest resources and produce	Analyse	1	2,4,5,6,7
3.	Develop and understanding the methods used in forest regeneration, land recreation, nursery and forest management, silviculture practices	Create	1	1,3,4,5,7,11,12
4.	Develop the skills in nursery preparation of forest trees, trending operations, forest mensuration, selection of trees in agro-forestry	Create	2	1,3,4,5,7,12
5.	Develop the ability to measure plant and tree growth, volume of felled and standing trees, ages of trees, natural and artificial regeneration, basal cover of forests.	Create	2	1,2,3,4,5,8,12

Mapping of Sustainable Development Goals (SDGs) and Indian Knowledge System (IKS)

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 2 – Zero Hunger	Ancient texts (*Vriksha Ayurveda*, *Krishi-Parashara*) describe scientific nursery raising, grafting, and propagation for food security.
SDG 6 – Clean Water & Sanitation	Traditional water harvesting structures (*Johads*, *Ahar-Pyne*, *stepwells*) integrated forestry and horticulture.
SDG 8 – Decent Work & Economic Growth	Indigenous agroforestry practices provided sustainable livelihoods (e.g., *Taungya system* in tribal regions).
SDG 9 – Industry, Innovation & Infrastructure	Traditional wooden ploughs, grafting knives, and irrigation wheels were early innovations adapted to local needs.
SDG 11 – Sustainable Cities & Communities	Ancient Indian city planning (e.g., Mohenjo-Daro) included green belts and planned tree planting.
SDG 12 – Responsible Consumption & Production	IKS emphasizes *Aparigraha* (minimal use of resources) and balanced use of land and forests.
SDG 13 – Climate Action	Traditional afforestation drives (e.g., *Van Mahotsav*, sacred groves) preserved forests and balanced ecosystems.

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 15 – Life on Land	*Sacred groves* (Devrai in Maharashtra, Saranas in Jharkhand) conserved biodiversity through cultural protection.

TEXTBOOKS:

1. Hawker, M. F. J. "Horticultural Machinery", 2011.
2. Robertson, J. "Mechanizing Vegetable Production". Farming Press, 2007
3. Lovergrove, H. T. "Crop Production Equipment". Hutchin son Educational Ltd., London, 1999.
4. Huggard E.R. and Owen T.H. "Forest Machinery", Adam & Charles Black Publishers Ltd, London, 1 Dec 1959.

REFERENCE BOOKS:

Hopfen, H. J. Small Farm Implements. F A O Agricultural Development Paper No.32, 1994

SKILLS:

1. Design of tools and equipment for forestry and horticulture
2. Field testing of designed tools and equipment used for forestry and horticulture



Image source link: https://2.imimg.com/data2/TP/HM/MY-397646/img-8-220x220.jpg

Image file name: Horticulture and Forestry Equipment

22FMB807 - CONTROLLED ENVIRONMENT AGRICULTURE

Hours per week:

L	T	P	C
2	0	2	**3**

PREREQUISITE KNOWLEDGE:

Basic knowledge of concepts and principles of controlled environment agriculture as well as basic skills, techniques and technologies of controlled environment agriculture.

COURSE DESCRIPTION AND OBJECTIVES:

To help students in knowing the growing of various crops in different regions controlling the various environmental factors such as temperature, humidity, irrigation, wind speed etc. and increasing the productivity. It will help the student in detail design of greenhouses by considering various factors. It is also useful for studying the various growth yield parameters in greenhouse and appropriate resource (natural) management in growing the crops.

MODULE-1

12L+0T+12P=24 Hours

UNIT-1

Introduction of controlled environment agriculture (CEA) as an agricultural alternative, micro climatic factors affecting on crop growth, methods for controlling the micro climatic factors.

UNIT-2

Greenhouse: Concept and historical background of green house, Classification of greenhouses based on shape, utility, covering material, cost of construction.

PRACTICES:

1.Recording of micro climatic factors inside green house

2.Comparative study of temperature and relative humidity of green house with covering materials.

3.Design of greenhouse to cover 20 m2 area.

4.Calculation of size of exhaust fans and suitable pad.

MODULE-2

18L+0T+18P=34 Hours

UNIT-1

Functions and features of green house, scope and development of greenhouse technology, location, planning and various components of greenhouse, criteria for design and construction of greenhouse, design load calculations, construction material, methods of construction, greenhouse covering

UNIT-2

Steady state analysis of greenhouse, Heating, cooling, shedding and ventilation of greenhouse, Carbon dioxide generation and monitoring and lighting systems, watering, fertilization, root substrate and pasteurization, Soil-Water-Plant relationships

UNIT-3

Portable instruments to control the greenhouse environment, Computerized environmental control of greenhouses, disease control and integrated pest management in greenhouse, nutrient management, cost analysis of greenhouse production.

PRACTICES:

1. Estimation of material requirement for construction of low cost green house
2. Calculation of requirement of heat of a green house in summer season.
3. Differentiate the temperature and relative humidity between inside and outside of greenhouse
4. Estimate the drying efficiency of green greenhouse for agricultural produce

COURSEOUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1.	Investigate regarding energy efficient cooling and ventilation technologies	4	1	1,2,4,6,8,10,11
2.	Investigate regarding properly adapted materials for high temperatures and strong solar radiation	4	1	1,2,4,5,6,8,10,11
3.	Sustainable and efficient water use methods	3	2	1,2,4,5,6

4.	Application of Automation principles inside the greenhouse	3	2	1,2,4,5,8,10
5.	Analyse the Accessibility of technologies regards greenhouses	3	2	1,2,5,6,8,10

Mapping of Sustainable Development Goals (SDGs) and Indian Knowledge System (IKS)

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 2 – Zero Hunger	Ancient practices like *Vriksha Ayurveda* described controlled conditions (shade nets, water channels) to improve yields.
SDG 3 – Good Health & Well-being	Traditional use of neem-based bio-pesticides and cow-based organic formulations (*Panchagavya*) ensured healthy produce.
SDG 6 – Clean Water & Sanitation	Indigenous *Ahar-Pyne*, *Kund*, and stepwell irrigation managed water efficiently for crops.
SDG 7 – Affordable & Clean Energy	Ancient sun-oriented architecture (e.g., *Vastu Shastra* principles) optimized natural light and ventilation.
SDG 9 – Industry, Innovation & Infrastructure	IKS innovations like grain storage silos, zero-energy cool chambers, and bamboo/poly-structures for crop storage inspire low-cost solutions.
SDG 12 – Responsible Consumption & Production	IKS promotes *Arthashastra* principles of resource optimization and eco-friendly material use (mud, bamboo, cow dung).
SDG 13 – Climate Action	Ancient *sacred groves* and *agroforestry* practices buffered local climate and preserved micro-climates.
SDG 15 – Life on Land	Traditional mixed-cropping and polyculture systems enhanced soil fertility and protected biodiversity.

TEXT BOOKS:

1. Salaokhe V. M. And Sharma, A. K. Greenhouse: Technology and Applications, Agrotech Publishing Academy, Udaipur 2006.

REFERENCE BOOKS:

1. Nelson, Paul V. Greenhouse: Operation and Management, Fifth Edition, Prentice Hall, Upper Saddle River, New Jersey, USA 2008.
2. Aldrich, R. A. And Bartok Jr. J. W. Greenhouse Engineering. Natural Resource, Agriculture and Engineering Service, Cooperative extension, 152 Riley-Robb Hall, Ithaca, NY14853-570, 2004.

SKILLS:

1. Design and construction of Greenhouse
2. Application of principles of Automation inside Greenhouse



Image source link:

https://th.bing.com/th/id/OIP.XcIr9Nwjlbs6ZMdJgyeOLAHaE8?rs=1&pid=ImgDetMain

Image file name: Controlled Environment Agriculture

22FMB808 - PRODUCT MANUFACTURING TECHNOLOGY

Hours per week:

L	T	P	C
2	0	2	**3**

PREREQUISITE KNOWLEDGE:

Basic knowledge of workshop technology and tool usage based on the materials

COURSE DESCRIPTION AND OBJECTIVES:

To acquire knowledge regarding construction of material and their characteristics, structure and properties of material, equilibrium diagram, time temperature transformation curves, heat treatment, types like metal, non-metal, alloy, non-alloy, measurement and quantity assurance, inspection and testing, casting process, forming process, material removal process, joining process, numeric control and process and techniques related to manufacturing.

MODULE-1

12L+0T+12P=24Hours

UNIT-1

Construction of material and their characteristics, structure of material, properties of material, equilibrium diagram, time temperature transformation curves, heat treatment, ferrous metals and alloys, non-ferrous metals and alloys, non-metallic material; plastic, elastomers, ceramics and composites, material selection, surface treatment and finishing. Measurement and quality assurance: Measurement and inspection, non-destructive inspection and testing, process capability and quality control, tolerance limits and clearances.

UNIT-2

PRACTICES:

1. Study of physical and mechanical properties of material tensile test, hardness, impact, material fatigue and endurance limit.
2. Study of metallographic structures of metals, determination of carbon and sulphur content, carburizing and hardening of plain and medium carbon steel by heating and annealing.

3. Study and use of measuring and inspection tools, study of limits, tolerances and geometric dimensioning.
4. Study and use of optical comparator, vision system measurement, co-ordinate measuring machine, surface roughness measurement, non-destructive inspection and testing and statistical process control
5. Study of physical and mechanical properties of material tensile test, hardness, impact, material fatigue and endurance limit.
6. Study of metallographic structures of metals, determination of carbon and sulphur content, carburizing and hardening of plain and medium carbon steel by heating and annealing.

MODULE-2

18L+0T+18P=36Hours

UNIT 1: CASTING AND FORMING PROCESS

Casting Process: Fundamentals of casting, patterns and sand moulds, continuous casting, shell moulding, lost wax or investment casting, plaster moulds, centrifugal casting, permanent mould casting, die-casting, electro-forming, the Shaw process and powder metallurgy.

Forming processes: Fundamentals of metal forming mechanism of hot and cold working,hot rolling of metals, forging processes, extrusion, cold rolling, cold forging, cold drawing, forming of plastic ceramic and composites, dies, shearing and blanking, and dies: bending and drawing.

UNIT-2

Material removal processes: Machining process, cutting tools for machining, turning and boring and related processes, drilling and related hole making processes, milling, broaching-sawing-filing, abrasive machining processes, work holding devices, machining centers, thread, manufacture, gear manufacturing and non-traditional machining processes (FCM, EDH, LBM, AJM, Wire EDM).

Joining processes: Gas flame processes: Cutting, welding and straightening, Arc processes, welding and cutting, resistance welding, brazing and soldering, adhesive, bonding and mechanical fasteners, manufacturing concerns in welding and joining.

UNIT-3

Numeric control: Command system, codes, programme, cutter position X and Y

incremental movements, linear contouring, Z movement and commands. Processes and Techniques related to manufacturing: Manufacturing system and automation, production systems and integrated manufacturing production system.

PRACTICES:

1. Study of pattern and sand moulding techniques, preparation of small moulds and carry out sand casting, study of different casting processes.
2. Practice on different machines like lathe, drill press, milling machine, slotting machine, shaper planers and grinders.
3. Study of non-traditional machining processes.
4. Study the tool geometry and their angles for different chip machining processes.
5. Study and practice on gas, arc, resistance, Mig and Tig welding, soldering, brazing and braze welding processes.
6. Study of surface finishing methods, cleaning, coaling and paint application. Carryout the practice on powder coating and painting by different methods.

COURSEOUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1.	Select appropriate Manufacturing processing to manufacture anycomponent	2	1	2,3,5,7,8,11
2.	Interpret foundry practices like pattern making, mould making, core making and inspection of defects	3	1	1,2,4,6,8,10,11
3.	Differentiate various metal forming process such as hot and cold working, rolling, forging and drawing processes.	3	2	1,3,5,6,7,8,9,10
4.	Develop simplified manufacturing processes with the aim of reduction of cost and manpower	6	2	1,3,4,6,8,10,11,12
5.	Implement the knowledge of gained subject in industry	6	2	1,3,4,6,8,9,10,11,12

Mapping of Sustainable Development Goals (SDGs) and Indian Knowledge System (IKS)

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 4 – Quality Education	Ancient *Shilpa Shastra* and *Vishwakarma traditions* provided knowledge on metalwork, sculpture, and precision tools for education and practice.
SDG 8 – Decent Work & Economic Growth	Traditional Indian guilds (*Shrenis*) organized artisans and craftsmen, promoting fair wages and quality workmanship.
SDG 9 – Industry, Innovation & Infrastructure	Historical innovations like *Wootz steel* and *Bidri metal crafts* show India's legacy in advanced metallurgy and sustainable materials.
SDG 12 – Responsible Consumption & Production	IKS practices like reuse of metals, natural finishing techniques, and sustainable alloy compositions reduced environmental burden.
SDG 13 – Climate Action	Indigenous knowledge of low-energy furnaces (charcoal-based iron smelting) reflects sustainable material processing.
SDG 15 – Life on Land	Use of natural dyes, plant-based adhesives, and clay moulds in traditional manufacturing ensured harmony with ecosystems.

TEXT BOOKS:

1. Fundamentals of Tool Design. American Society of Tool and Manufacturer Engineers. Gupta, R. B. Production Technology, 2004
2. Jain, R. K. Production Technology: A Text book for Engineering Students. Khanna Publishers, New Delhi1994.

REFERENCE BOOKS:

1. Myron; Begeman, L. and Amstead, B. H. Manufacturing Processes, 2015
2. Polukin, P. Gringerg, B. K antenik, S. Zhadan, V. And Vasilye, D .Metal Process Engineering, MIR Publishes. Moscow, 2008
3. Chapman, (Part III). Working Technology, 2008

SKILLS:

- Design and development of simple tolling for shearing, bending and deep drawing and use the main workshop
- Developing a programme for CNC machines (turning and milling) and practice on operation of turning and milling centers
- Study and design of different types of joints for welding. Welding of different

materials ferrous, cast iron, non-ferrous and stainless steel.

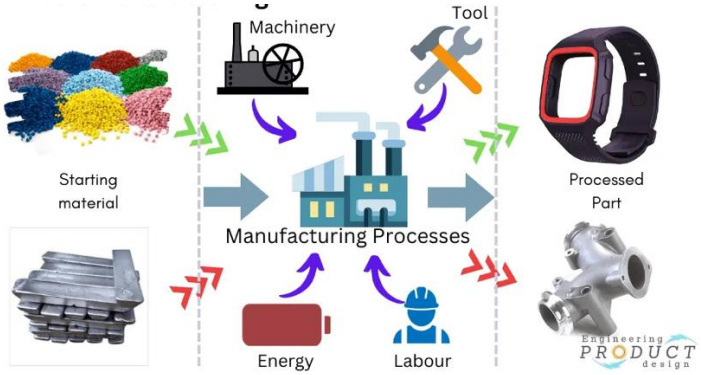


Image source link:
https://www.google.com/url?sa=i&url=https%3A%2F%2Fengineeringproductdesign.com%2Fknowledge-base%2Fmanufacturing-processes%2F&psig=AOvVaw2aBtis4TGMdbwldCpWuNTa&ust=1741483590670000&source=images&cd=vfe&opi=89978449&ved=0CBQQjRxqFwoTCJDnjJCq-YsDFQAAAAAdAAAAABAE
Image file name: Product Manufacturing Technology

22FMB809 - FARM MACHINERY DYNAMICS, NOISE AND VIBRATION

Hours per week:

L	T	P	C
2	0	2	**3**

PREREQUISITE KNOWLEDGE:

Basic knowledge about working tools of primary and secondary tillage equipment's

COURSE DESCRIPTION AND OBJECTIVES:

To acquaint with principles of soil working tools: shares, discs and shovels and blades, metering of seeds and granular fertilizers with various mechanisms, electrostatic spraying and dusting, spray distribution patterns, kinematics of reapers, parameters affecting performance of threshers, noise and vibration theory – definitions, units and parameters of measurements and their importance, types of vibrations and balancing of single rotating weight in same plane, balancing of reciprocating parts of engine.

MODULE-1

UNIT-1 **8L+0T+8P=16 Hours**

Principles of soil working tools: shares, discs and shovels and blades, vibrating tillage tools and impact of vibration in saving of energy.

UNIT-2 **8L+0T+8P=16 Hours**

Metering of seeds and granular fertilizers with various mechanisms, effect of various parameters on distribution of seed and fertilizer in seed-cum-fertilizer drills and planters. Electrostatic spraying and dusting, spray distribution patterns, kinematics of reapers, parameters affecting performance of threshers.

PRACTICES:

1. Testing of seed metering mechanism of seed drill
2. Calibration of sprayers and dusters and adjustments
3. Testing of granular fertilizer material broad caster
4. Performance evaluation of power thresher

MODULE-2

UNIT-1 **8L+0T+8P=16Hours**

Noise and vibration theory – definitions, units and parameters of measurements and

their importance. Types of vibrations–free and forced vibrations.

UNIT-2 **8L+0T+8P=16 Hours**

Balancing of single rotating weight in same plane, balancing of reciprocating parts of engine.

PRACTICES:

1. Study of vibration measurement and analysis equipment.
2. Study of different vibration measurement and evaluation.
3. Measurements of forced vibrations

SKILLS:

- Measurement and analysis of vibration on different components of thresher and tractors
- Evaluation of damping factor for a given material
- Application of principles of modulus of elasticity for a given material.

COURSEOUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1.	Understand the kinematics and dynamics of various farm power and machinery systems	2	1	2,3,5,7,8,11
2.	Apply the principles of kinematics and dynamics for the design and development of farm machines	3	1	1,2,4,6,8,10,11
3.	Analysing and understanding noise and vibration theory and apply in design of farm machines	4	2	1,2,4,6,8,10,11
4.	Understanding the concept of balancing the reciprocating parts of engine	2	2	2,3,5,7,8,11
5.	Apply the concept of balancing the single rotating weight in design of farm machines	3	2	1,2,4,6,8,10,11,12

Mapping of Sustainable Development Goals (SDGs) and Indian Knowledge System (IKS)

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 2 – Zero Hunger	Traditional seed drills (*Naru yantra*, *Khurpi* methods) ensured uniform sowing and minimal wastage in ancient India.
SDG 7 – Affordable & Clean Energy	Indigenous ploughs and tools optimized draft power from bullocks, reducing energy needs naturally.
SDG 8 – Decent Work & Economic Growth	*Krishi Shastras* guided farmers on efficient implements for different soils, ensuring better labor efficiency.
SDG 9 – Industry, Innovation & Infrastructure	Ancient engineering texts like *Samarangana Sutradhara* documented machine design principles, inspiring indigenous innovations.
SDG 12 – Responsible Consumption & Production	Traditional farming emphasized exact seed placement, crop rotation, and organic manuring for sustainable production.
SDG 13 – Climate Action	Indigenous minimal tillage practices like *zero till* with bullock-drawn ploughs conserved soil and reduced carbon impact.
SDG 15 – Life on Land	Ancient contour ploughing and intercropping preserved soil health and biodiversity in Indian farming systems.

TEXT BOOKS:

1. Kepner, R. A. Bainer, R, and Barger E. L. Principles of Farm Machinery, A VI Pub.,
2. Grover G K. Mechanical Vibrations. New Chand and Broths. Roorkee, 2007
3. MeirovitchL. Elementsof vibrationanalysis. IIEdition. McgrawHill, 2007

REFERENCE BOOKS:

1. Bosoi, E. S. Vermiaev, O V, Smirnov, I-I and Sultan Shakh, E. G. Theory, Construction and Calculation of Agricultural Machines, A. A. Balkema Poub. Rot terdam, 2009
2. Kanafozski, O and T. Karwowski Agricultural Machines: Theory and Construction. Vol.I & II, Translated and published by US Deptt. Of Agriculture, 2008

Image source link:

Image file name:

22FMB810 - ENGINEERING PROPERTIES OF FOOD MATERIALS

Hours per week:

L	T	P	C
2	0	2	**3**

PREREQUISITE KNOWLEDGE:

Fundamental knowledge of all types of fruits and vegetables and basics of engineering fundamentals

COURSE DESCRIPTION AND OBJECTIVES:

To learn about different techniques of measurement of engineering properties and their importance in the design of processing equipment's, determine physical, aerodynamic and thermal properties of food; identify the causes of mechanical damage.

MODULE-1

12L+0T+12P=24Hours

UNIT-1

Importance and brief description of mechanical; thermal; electrical and optical properties; Physical characteristics - shape; size; charted standards; roundness; sphericity; axial dimensions and projected area.; volume and density - platform scale; specific gravity balance; pycnometer method; porosity and surface areas – leaf and stalk surface area; fruit surface area; egg surface area and specific surface in porous pack.

UNIT-2

Basic concepts of rheology, physical states of material; rheological models and Rheological equations, Maxwell, Kelvin, 4-element model, generalized Maxwell and Generalized Kelvin models; viscoelastic characterization of materials - stress; strain behavior; creep, stress relaxation and dynamic tests.

PRACTICES:

1. Determination of physical properties like, length, breadth, thickness, surface area of biological materials.
2. Determination of bulk density, porosity and true density of a biological materials
3. Determination of volume of any irregular surface biological materials
4. Determination of terminal velocity of biological materials.

MODULE-2

18L+0T+18P=36 Hours

UNIT-1

Textural and structural mechanics of food materials, effect of age, water content and temperature on texture of foods, introduction to rheological characteristics of agricultural, dairy and food products.

UNIT-2

Mechanical damage – economic importance; causes; detection and evaluation of mechanical damage. Impact damage and its mechanics; vibration damage and stress cracking; Maximum allowable load for agricultural products.

UNIT-3

Aero- and hydro-dynamic characteristics - Drag coefficient; terminal velocity; separation of foreign materials; pneumatic transport and handing; effect of moisture on frictional properties, angle of internal friction; angle of repose, application of frictional properties in design of handling and processing machines such as screw conveyors and oscillating conveyors.

PRACTICES:

1. Determination of coefficient of friction and angle of repose.
2. Determination of colour for various food grains, fruits, vegetables, spices and processed foods.
3. Determination of thermal properties like specific heat of food materials.
4. Determination of rheological properties like firmness and hardness of grain and fruits.

COURSEOUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Estimate the porosity of biological materials by using pycnometer	5	1	1,2,4,5,6,8,9,10,11
2	Application of Maxwell and Kelvin models for biological materials for studyof different properties	3	1	1,2,4,6,8,10,11
3	Detect and evaluate the mechanical damage for agricultural products	5	2	1,2,4,5,6,8,9,10,11
4	Application of pneumatic transportation principles for transportation of sensitive biological materials	3	2	1,2,4,6,8,10,11
5	Design of screw conveyors for conveying of fruits and vegetable	6	2	1,3,4,6,8,10,11,12

Mapping of Sustainable Development Goals (SDGs) and Indian Knowledge System (IKS)

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 2 – Zero Hunger	Ancient grain storage structures (*Kuthar*, *Golaghar*, mud silos) used natural aeration and porosity principles to protect grains.
SDG 3 – Good Health & Well-being	Ayurveda emphasized food texture (*guna*) and properties (*rasa*, *virya*) for human well-being.
SDG 7 – Affordable & Clean Energy	Indigenous tools like *chakki* (hand mill) and water-powered mills applied natural energy-efficient principles.
SDG 8 – Decent Work & Economic Growth	Traditional cooperative grain processing (village-level *chakki* and oil expellers) supported rural economies.
SDG 9 – Industry, Innovation & Infrastructure	Ancient Indian metallurgy and material science (iron pillars, alloys) reflect deep indigenous knowledge of material properties.
SDG 12 – Responsible Consumption & Production	Traditional threshing, winnowing, and hand-processing methods minimized breakage and waste.
SDG 13 – Climate Action	Indigenous low-energy storage and handling practices (mud pots, bamboo bins) reduced environmental impact.
SDG 15 – Life on Land	Ancient sustainable harvesting and storage practices (like underground pits for tubers) protected food diversity.

REFERENCE BOOKS:

1. Bourne, M. 2002. Food Texture and Viscosity–Concept and Measurement. Academic Press.
2. Mohesenin N N. 2000. Physical Properties of Plant and Animal Materials. Gordon & Breach Science Publ.
3. Peleg M & Bagelay E B. 1983. Physical Properties of Foods. AVI Publ. Co.
4. Rao M A & Rizvi S S H. (Eds). Engineering Properties of Foods. Marcel Dekker.
5. Rao M A, Rizvi S S H & Datta A D K. 2005. Engineering Properties of Food. Francis and Taylor, C R C press.
6. Sahin S & Sumnu S G. 2006. Physical Properties of Food. Springer.
7. Singhal O P & Samuel D V K. 2003. Engineering Properties of Biological Materials.

SKILLS:

- Determination of colour of food materials
- Determination of thermal and rheological properties of food materials
- Determination of angle of repose for different floor materials

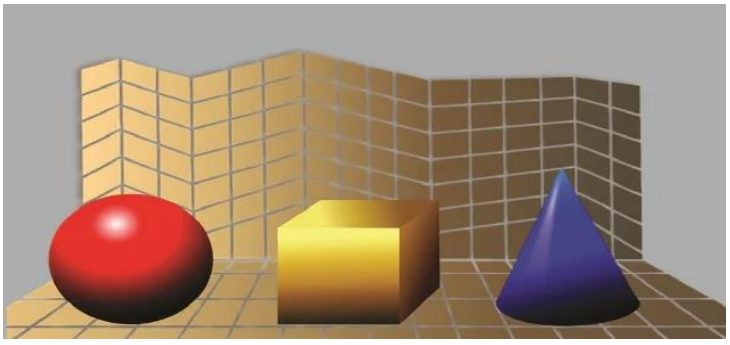


Image source link:
https://www.google.com/url?sa=i&url=https%3A%2F%2Fagrimoon.com%2Fengineering-properties-of-biological-materials-and-food-quality-pdf%2F&psig=AOvVaw0VMfTfsw2ODEj3RN12BniI&ust=1741483223273000&source=images&cd=vfe&opi=89978449&ved=0CBQQjRxqFwoTCLDJ9duo-YsDFQAAAAAdAAAAABAE
Image file name: Engineering Properties of Food Materials

22FMB811 - GEO-INFORMATICS AND NANO-TECHNOLOGY FOR PRECISION FARMING

Hours per week:

L	T	P	C
2	0	2	**3**

PREREQUISITE KNOWLEDGE: Indian agriculture; Precision Agriculture, fertilizer recommendation.

COURSE DESCRIPTION AND OBJECTIVES:

To introduce the basic concepts of geo-informatics and nanotechnology, create awareness about various applications of geo-informatics and nanotechnology for precision agriculture, teach basic handling of various geo-informatics tools

MODULE-1

12L+0T+12P= 24 Hours

UNIT-1: PRECISION AGRICULTURE

Concepts and techniques, their issues and concerns for Indian agriculture;

Geo-informatics**:** Definition, concepts, tool and techniques, their use in precision agriculture, introduction to GIS software, data creation and editing.

UNIT-2: APPLICATION OF REMOTE SENSING

Crop discrimination and Yield monitoring, soil mapping; fertilizer recommendation using geospatial technologies; Spatial data and their management in GIS; Remote sensing concepts and application in agriculture; Image processing and interpretation

PRACTICES:

1. Application of GIS software to create spatial data regards agriculture.
2. Introduction to image processing software.
3. Introduction to Visual and digital interpretation of remote sensing images.
4. Generation of spectral profiles of different objects.

MODULE-2

18L+0T+18P=36 Hours

UNIT 1: GLOBAL POSITIONING SYSTEM (GPS)

Introduction, components and its functions. Introduction to crop simulation models and their uses for optimization of agricultural inputs; STCRapproach for precision agriculture;

UNIT 2: NANOTECHNOLOGY

Definition, concepts and techniques, brief introduction about nano-scale effects, nano-particles, nano-pesticides, nano-fertilizers, nano-sensors

UNIT 3: USE OF NANOTECHNOLOGY

Use of nano- technology in seed, water, fertilizer and plant protection for scaling-up farm productivity.

PRACTICES:

1. Crop stress (biotic/abiotic) monitoring using geospatial technology.
2. Find out some locations of agricultural fields by using GPS.
3. Formulation, characterization and applications of nano-particles in agriculture.
4. Projects formulation and execution related to precision farming.
5. Creation of thematic layers of soil fertility based on GIS.
6. Multispectral remote sensing for soil mapping.

COURSEOUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1.	Analyse of spatial and temporal variability ofthe input parameters using primary data at field level	Analyse	1	2,4,5,7
2.	To Analyse both economic and environmental issues that surround production agriculture today.	Analyse	2	1,2,4,5,6
3.	To create awareness about various applications of geo-informatics and nanotechnology for precision agriculture	Create	2	2,3,4,5
4	Introduction to crop Simulation Models and their uses for optimization of Agricultural Inputs	Create	2	3,4,5,8

5	scaling-up farm productivity by using nanotechnology	Create	2	1,2,3,4,5,7,8,9,12

Mapping of Sustainable Development Goals (SDGs) and Indian Knowledge System (IKS)

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 2 – Zero Hunger	Ancient India practiced site-specific farming (*Bhoomi Pariksha* in texts like *Krishi-Parashara*), analyzing soil, water, and climate before cultivation.
SDG 3 – Good Health & Well-being	Traditional organic pest management (Neem extracts, cow urine, Panchagavya) focused on safe, natural crop protection.
SDG 6 – Clean Water & Sanitation	Ancient irrigation systems like *Ahar-Pyne*, *Johads*, and tank irrigation reflected sustainable water use.
SDG 7 – Affordable & Clean Energy	Traditional low-energy irrigation devices (*Persian wheel*, *Rahat*, *Sakia*) optimized renewable water lifting.
SDG 8 – Decent Work & Economic Growth	Village cooperative farming and *Kulkarni* records (land productivity registers) were traditional models of rural economic growth.
SDG 9 – Industry, Innovation & Infrastructure	Indigenous astronomical observations and *Jyotisha* were used historically to determine seasons and crop calendars.
SDG 12 – Responsible Consumption & Production	Traditional mixed cropping and crop rotation promoted natural soil fertility and efficient resource use.
SDG 13 – Climate Action	Ancient texts like *Brihat Samhita* documented monsoon prediction methods based on wind, clouds, and animal behavior.
SDG 15 – Life on Land	Traditional agroforestry systems (e.g., *Vrikshayurveda* practices) promoted balance between crops, trees, and soil health.

TEXT BOOKS:

1. Reddy S R. Geo-informatics and Nano-technology for Precision Farming, Kalyani Pub., 2017.
2. Upadhyay Tarun Kumar and Sharma Sushil Kumar. Textbook on Geo-informatics, Nano-technology and Precision Farming, ND Pub., 2020.

REFERENCE BOOKS:

1. Chandra A M. Geo-Informatics, New Age International, July 15, 2016

SKILLS:

- Application of geospatial technologies to find out the fertilizer recommendation
- Application of nanotechnology in seed, water, fertilizer, plant protection for scaling-up farm productivity.

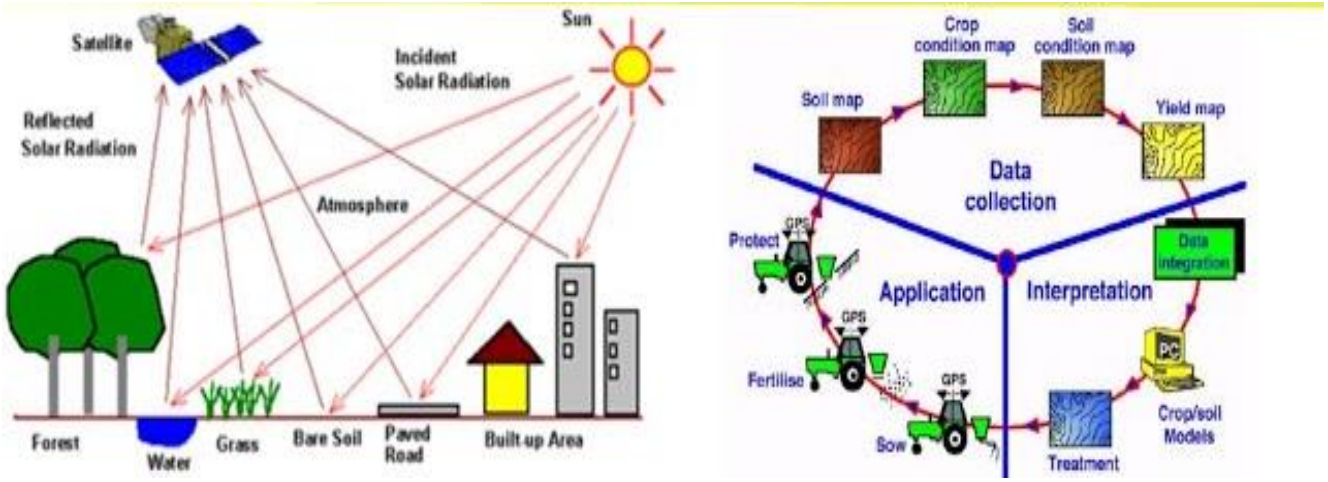


Image source link:
https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.youtube.com%2Fwatch%3Fv%3DuuAT7mMa9pg&psig=AOvVaw1a-PzG7Zzj2Za8lwMM9YWi&ust=1741482957950000&source=images&cd=vfe&opi=89978449&ved=0CBQQjRxqFwoTCJC0yN6n-YsDFQAAAAAdAAAAABAE
Image file name: Geo-Informatics and Nano-Technology For Precision Farming

22FMB812 - DIMENSIONAL ANALYSIS AND SIMILITUDE

Hours per week:

L	T	P	C
2	0	2	**3**

PREREQUISITE KNOWLEDGE:

Units and Dimensions, Introduction of stress and strain, Fundamental of Fluid mechanics and Heat Transfer

COURSE DESCRIPTION AND OBJECTIVES:

This course will give the knowledge about the basic parameters to be considered in the design of the machineries also transformation of product, various possible for ces and it's extents on the model in working. It will help students the way of testing of model from similitude design. Also student will study the behavior of fluids to be used in the model, heat transfer and electromagnetic phenomenon in application of similitude.

MODULE-1

12L+0T+12P=24 Hours

UNIT-1: DIMENSIONAL ANALYSIS:

Need, scope, methods, advantages and limitation of dimensional analysis. The classification of physical quantities. Transformation of units of measurement.

UNIT-2

The principle of dimensional homogeneity, the structure of the typical equation on the basis of the dimensional analysis, complete sets of dimensionless products, Buckingham Pi theorem

PRACTICES:

1. Study of method of transformation of units of measurement.
2. Calculation of dimensionless homogeneity.
3. Calculation of dimensionless products.
4. Calculation of problems related to Pi-theorem and its application.

MODULE-2

UNIT 1 **18L+0T+18P=36 Hours**

Dimensionless parameter and its parameters, transformation of dimensionless products, similarity and model testing.

UNIT 2

Dimensional analysis applied to problem of stress and strain.

UNIT 3

Dimensional number of fluid mechanics, heat transfer and electromagnetic theory, similitude studies, types and applications, model analysis.

PRACTICES:

1. Method for finding out determinants.
2. Methods for transformation of dimensionless products.
3. Study of procedure for model testing.
4. Problem solving related to stress and strain, fluid mechanics, heat transfer and electromagnetic theory.

COURSEOUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1.	To Identify the forces that govern the physical processes and select the relevant dimensionless parameters to simplify the experimental setup using critical thinking skills.	Analyse	1	2,4,5.6
2.	To apply dimensional analysis to predict formulas which connect particular variables in given circumstance	Apply	1	1,5,6,7,8
3.	To design a model to investigate the relevant physical processes and mechanisms through experiments using engineering judgement.	Create	2	3,4,5,7,12
4.	To develop relationships for the parameter of interest by correlating the experimental data and dimensionless parameters.	Create	2	2,4,5,7,11

Mapping of Sustainable Development Goals (SDGs) and Indian Knowledge System (IKS)

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 4 – Quality Education	Ancient Indian scholars (Āryabhaṭa, Bhāskara, Varāhamihira) used mathematical logic and proportionality principles to describe planetary motion, geometry, and physical processes.
SDG 7 – Affordable & Clean Energy	Traditional water-lifting devices (*Rahat*, *Shaduf*) and wind-driven systems were tested on scaled models before real applications.
SDG 9 – Industry, Innovation & Infrastructure	Ancient India applied scale models in architecture (*Shilpa Shastra*) and temple construction to ensure structural stability and symmetry.
SDG 11 – Sustainable Cities & Communities	Town-planning of *Mohenjo-Daro* and *Harappa* reflected proportion, geometry, and hydraulic modeling of drainage systems.
SDG 12 – Responsible Consumption & Production	Traditional *Vaastu Shastra* emphasized material efficiency and proportional use in construction and design.
SDG 13 – Climate Action	Ancient texts like *Brihat Samhita* recorded observations of rainfall, floods, and winds, applying proportional analysis to natural phenomena.

TEXT BOOKS:

1. Modi and Seth. Hydraulic and Fluid Mechanics, published by Standard Book House, New Delhi, 1991.
2. Longo G. Sandro. Principles and Applications of Dimensional Analysis and Similarity, Springer International Publishing AG 2021

REFERENCE BOOKS:

1. Langhaar, I. Henry I. Dimensional Analysis and Theory of Model. Published by John Wiley and Sons. Inc. London, 1951.
2. Jagdish Lal. Hydraulic and Fluid Mechanics, Published by Metropolitan Book Co. Delhi, 1983.

SKILLS:

- Transformation of units of measurement.
- Application knowledge Buckingham pi theorem

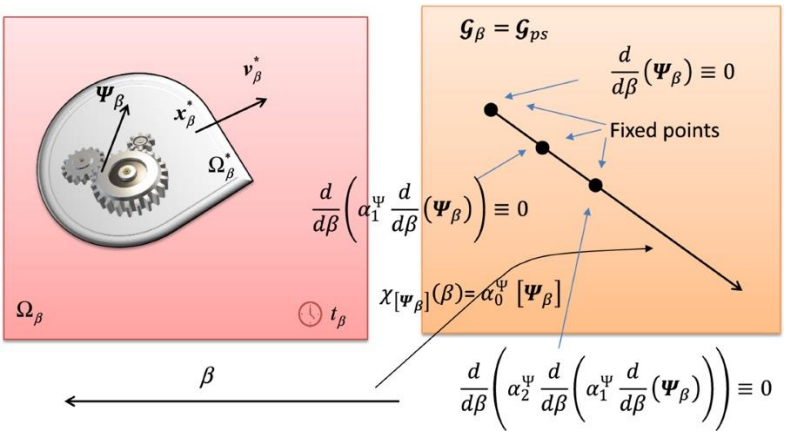


Image source link:
https://www.google.com/url?sa=i&url=https%3A%2F%2Flink.springer.com%2Farticle%2F10.1007%2Fs10665-023-10296-1&psig=AOvVaw0Re6kRKNGVt-QygYLN8A59&ust=1741482258419000&source=images&cd=vfe&opi=89978449&ved=0CBQQjRxqFwoTCICRxKam-YsDFQAAAAAdAAAAABAE
Image file name: Dimensional Analysis and Similitude

22FMB813 – MACHINERY FOR HORTICULTURE AND PROTECTED AGRICULTURE

Hours per week:

L	T	P	C
2	-	2	**3**

PREREQUISITE KNOWLEDGE: Introduction to Horticulture or Agricultural Machinery

COURSE DESCRIPTION AND OBJECTIVES:

This course introduces students to the principles, design, and operation of machinery and equipment used in horticulture and protected agriculture. It covers various types of machinery and their applications in controlled environments like greenhouses and nurseries.

MODULE-1

12L+0T+12P=24 Hours

UNIT-1: INTRODUCTION TO MACHINERY IN HORTICULTURE

Definition and scope of machinery in horticulture, Historical perspective and technological advancements, Importance of mechanization in horticulture.

Types of Horticultural Machinery: Tractors and tractor attachments, Planting and transplanting machinery, Harvesting and post-harvest handling equipment, Irrigation and water management machinery.

UNIT-2: PROTECTED AGRICULTURE STRUCTURES

Introduction to protected agriculture (greenhouses, tunnels, etc.), Design and components of greenhouse structures, Environmental control systems in protected agriculture.

Machinery for Greenhouse Operations: Heating, cooling, and ventilation equipment, Automated climate control systems, Irrigation and fertigation systems in protected environments.

PRACTICES:

1. Basic tractor maintenance, including oil changes and filter replacement.
2. Calibration and adjustment of planting machinery for different crops.
3. Hands-on experience with soil sensors and weather stations.
4. Installation and operation of environmental control systems.

MODULE-2

18L+0T+18P= 34 Hours

UNIT 1

Precision Agriculture in Horticulture: Precision agriculture concepts and technologies, Sensor-based applications in horticulture, Data management and analysis for precision horticulture.

Machinery for Pest and Disease Management: Sprayers and dusters for pesticide application, Monitoring and control systems for pest and disease management.

UNIT 2: POST-HARVEST HANDLING AND PROCESSING MACHINERY

Sorting, grading, and packaging machinery, Cold storage and refrigeration systems.

Machinery Maintenance and Safety: Routine maintenance and troubleshooting, Safety protocols for machinery operation.

UNIT 3: Emerging Technologies in Horticultural Machinery

Automation and robotics in horticulture, Drones and remote sensing applications.

Sustainable Practices and Future Trends: Sustainable machinery and energy-efficient practices, Future trends and innovations in horticultural machinery.

PRACTICES:

1. Calibration of a pesticide sprayer.
2. Post-harvest handling of fruits and vegetables
3. Machinery maintenance and safety checks
4. Drone-based monitoring of crop health.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1.	Demonstrate safe operation of horticultural machinery, adhering to standard operating procedures and safety guidelines.	Apply	1	2,4,5,8
2.	Calibrate and adjust planting and irrigation machinery to achieve precise seed placement, spacing, and water distribution for different crops	Apply	1	1,2,5,6
3.	Develop a design proposal for a controlled environment in horticulture, considering structural elements, climate control, and energy efficiency.	Create	2	1,3,5,8,9
4.	Evaluate the impact of controlled environment management on crop growth and yield, using data to make adjustments for optimal conditions.	Evaluate	2	4,5,7,8
5.	Design innovative modifications to horticultural	Create	2	3,5,7,9,11

	machinery to enhance sustainability, energy efficiency, or crop-specific adaptability.			

Mapping of Sustainable Development Goals (SDGs) and Indian Knowledge System (IKS)

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 2 – Zero Hunger	Ancient India developed fruit/vegetable preservation (e.g., drying, pickling, storage pits) and water-lifting devices (*shaduf*, *rahat*) to secure food supply.
SDG 3 – Good Health & Well-being	Traditional pest control (Neem extracts, Panchagavya, smoke fumigation) emphasized safe and eco-friendly practices.
SDG 4 – Quality Education	Ancient *Gurukula* and *Krishi-Parashar* texts emphasized experiential learning, observation, and hands-on agricultural education.
SDG 7 – Affordable & Clean Energy	Traditional use of solar heat traps, passive ventilation, and water-based cooling in *stepwells* and storage houses.
SDG 8 – Decent Work & Economic Growth	Indigenous community farming practices and cooperative irrigation systems ensured equitable work distribution.
SDG 9 – Industry, Innovation & Infrastructure	Ancient hydraulic engineering (e.g., *Kallanai dam*, *Harappan irrigation channels*) showed technological ingenuity in agriculture.
SDG 11 – Sustainable Cities & Communities	Ancient Indian *home gardens* and *sacred groves* provided community-based sustainable horticulture models.
SDG 12 – Responsible Consumption & Production	Traditional grain storage structures (*Kuthar*, mud bins, bamboo silos) minimized losses and ensured food quality.
SDG 13 – Climate Action	Traditional water management (tank irrigation, stepwells, rainwater harvesting) helped communities adapt to climate challenges.
SDG 15 – Life on Land	Ancient texts promoted mixed cropping, agroforestry, and organic inputs to maintain ecological balance.

TEXT BOOKS:

1. Bell Brian, Stewart Cousins (1997). Machinery for Horticulture. Old Pond Publishing Ltd; 2nd Revised edition.
2. Stafford John (2018). Precision Agriculture for Sustainability. Burleigh Dodds Science Publishing, London.
3. Mefferd Andrew (2017). The Greenhouse and Hoophouse Grower's Handbook: Organic Vegetable Production Using Protected Culture. Chelsea Green Publishing,
4. Hanan Joe J. (2017). Greenhouses: Advanced Technology for protected Horticulture.

CRC Press.

SKILLS:

- Horticulture Machinery Calibration and Adjustment
- Precision Agriculture Data Collection
- Sustainable Machinery Practices



Image Source Link : https://www.freepik.com/premium-vector/vector-set-agricultural-vehicles-farm-machines-tractors-harvesters-combines-illustration-flat-design-agriculture-business-concept-agriculture-machinery-agriculture-crop-harvest_4668781.html
Image file name: Machinery for Horticulture and Protected Agriculture

22FMB814 - MACHINERY FOR PRECISION AGRICULTURE

Hours per week:

L	T	P	C
2	0	2	**3**

PREREQUISITE KNOWLEDGE:

Fundamental knowledge of precision agriculture and different types of machinery used for particular operations.

COURSE DESCRIPTION AND OBJECTIVES:

This course introduces the students with precision farming technologies and different types of conservation agricultural machineries for natural resource management. It will give the different engineering fundamentals of conservation machineries, construction and operation of different machineries and their suitability for operations and different types of related computer programmes such as critical path methods (CPM).

MODULE-1

12L+0T+12P=24 Hours

UNIT-1: FUNDAMENTALS OF PRECISION FARMING

An introduction to precision farming, issues and conditions. Engineering fundamentals related to earth-moving machinery, swell and shrinkage, type of compacting equipment, land clearing equipment.

UNIT-2: EARTH MOVING MACHINERY

Power shovel: Construction and operation of power shovel, size selection of power shovel, factors affecting the output of a power shovel.

Dragline: Types of dragline, size, basic parts and operation of a dragline, output of adragline, estimation of output, effect of different factors on output, numerical problems.

Practices:

1. Design specification sheet of earth moving machinery
2. Design specification sheet of land clearing machinery
3. Study of power shovel and solve numerical problems
4. Study of drag line and solve numericals

MODULE-2

18L+0T+18P=34 Hours

UNIT 1: CLAM SHELL

Basic parts and operation of a clam shell, application, size and output of a clam shell.

UNIT 2: TRENCHING MACHINES

Types, construction and operation of wheel and ladder type trenching machines, selection of suitable equipment for excavating trenches and production rates of trenching machines.

UNIT 3: JOB PLANNING AND MANAGEMENT

Project network analysis, definitions of terms used in critical path method (CPM), critical path scheduling, AOA diagram, computerizedscheduling.

PRACTICES:

1. Study of clamshell.
2. Estimate of earth work of trenching machines
3. Estimate unit cost of operation of machinery
4. Problems related to land development using CPM machines used for natural recourses management and precision farming.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Analysis of precision farming, issues and conditions.	Analyse	1	2,4,5,6
2	Analysis of engineering fundamentals related to earth-moving machinery, swell and shrinkage,	Analyse	1	2,4,5,6,7,9
3	Selection of suitable equipment for excavating Trenches and production rates of trenching machines	Apply	2	1,2,5,11
4	Application of critical path scheduling	Apply	2	1,2,5,6,8
5	Analysis of Job planning and management	Analyse	2	2,4,5,6,7,9,10

Mapping of Sustainable Development Goals (SDGs) and Indian Knowledge System (IKS)

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 2 – Zero Hunger	Ancient practices like *bunding, terracing, and pond irrigation* maximized crop output per unit area.
SDG 7 – Affordable & Clean Energy	Traditional land preparation using animal-drawn implements minimized energy use.
SDG 8 – Decent Work & Economic Growth	Community-based labor-sharing systems (*Shramdaan*, *Goseva*) optimized manpower in land preparation.
SDG 9 – Industry, Innovation & Infrastructure	Historical water-lifting devices (*rahat*, Persian wheel) and terracing systems show innovation in land development.
SDG 11 – Sustainable Cities & Communities	Traditional land-use planning, including village ponds, bunds, and irrigation channels, ensured sustainable local resource management.
SDG 12 – Responsible Consumption & Production	Ancient farming practices emphasized resource-efficient land leveling and terracing to reduce soil erosion.
SDG 13 – Climate Action	Indigenous land management techniques like staggered cropping and contour farming mitigated climate impacts.
SDG 15 – Life on Land	Agroforestry and forest management practices conserved soil fertility and biodiversity while preparing land for cultivation.

TEXT BOOKS:

1. Purifoy R., Schexnayder C.J. and Shapira Aviad. Construction Planning, Equipment and Methods, 7th Edition, McGraw Hill Education, India, 22 May 2010.
2. De Amitosh. Latest Development of heavy earth moving machinery, Galgotia Publication pvt ltd, New delhi, 1 January 2015.

REFERENCE BOOKS:

1. Verma Mahesh. Construction equipment and its planning and application, 2nd Edition, Metropolitan Book Company, New Delhi, 1975.
2. Michael, A.M., Irrigation theory and practices, 2nd Edition, S. Chand, New Delhi, 1st January 2008

SKILLS:

- Operation of power shovel, size selection of power shovel
- Construction and operation of wheel and ladder type trenching machines
- Job planning and management



Image Source Link :

https://www.google.com/url?sa=i&url=https%3A%2F%2Feos.com%2Fblog%2Fprecision-agriculture%2F&psig=AOvVaw2F1tIIQdgJVWfl7uiFrJHU&ust=1741479877043000&source=images&cd=vfe&opi=89978449&ved=0CBQQjRxqFwoTCMjd7p2c-YsDFQAAAAAdAAAAABAJ

Image file name: Machinery for Precision Agriculture

22FMB815 - FOUNDATION SKILLS IN INTEGRATED PRODUCTDEVELOPMENT

Hours per week:

L	T	P	C
2	0	2	**3**

PREREQUISITE KNOWLEDGE: To excel in integrated product development, one should possess foundation skills in design and development, engineering and technology, project management and collaboration, business and marketing, and sustainability and social responsibility. This includes knowledge of design principles, engineering fundamentals, project management, market research, and sustainability principles. Additionally, proficiency in design tools, communication skills, and collaboration are essential.

COURSE DESCRIPTION AND OBJECTIVES:

To understand the global trends and development methodologies of various types of products and services, conceptualize, prototype and develop product management plan for a new product based on the type of the new product and development methodology integrating the hardware, software, controls, electronics and mechanical systems, understand requirement engineering and know how to collect, analyze and arrive at requirements for new product development and convert them in to design specification.

MODULE-1

12L+0T+12P=24 Hours

UNIT-1: FUNDAMENTALS OF PRODUCT DEVELOPMENT

Global Trends Analysis and Product decision: Social trends, technical trends economic trends, environmental trends, political/policy trends.

Introduction to Product Development Methodologies and Management: Overview of products and services, types of product development, overview of product developmentmethodologies, product life cycle, product development planning and management.

UNIT-2: REQUIREMENTS AND SYSTEM DESIGN

Requirement Engineering: Types of requirements, requirement engineering traceability matrix and analysis, requirement management.

System Design & Modelling: Introduction to system modelling, system optimization, system specification, sub-system design, interface design

Practice:

1. Study of methodologies of product development
2. Create new product development documentation
3. Create interface design on product development life cycle.
4. Create system modelling on new product development in CAM Software

MODULE-2

18L+0T+18P=36 Hours

UNIT 1: DESIGN AND TESTING

Conceptualization: Industrial design and user interface design, introduction to concept generation techniques.

UNIT 2: INTEGRATION OF ENGINEERING DISCIPLINES

Challenges in Integration of Engineering Disciplines: Concept, screening & evaluation.

UNIT 3: DETAILED COMPONENT DESIGNING

Component design and verification.

Mechanical, Electronics and Software Subsystems: High level design/low level design of S/W program, types of prototypes, S/W Testing-Hardware schematic, component design, layout and hardware testing.

Practice:

1. Case study: To perform various testing using the testing tool unit testing, integration testing for a sample code of the suggested system.
2. Create layout for designing Mechanical type sub-system for new product development
3. Create layout for designing Electronics type sub-system for new product development
4. Software testing

COURSEOUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Analyse and formulate a problem	Analyse + Evaluate	1	1,2,4,5,6,7,9
2	Solve specific problems independently or as part of a team	Evaluate	1	3,5,9,11
3	Mastering the methods and processes of design.	Create	2	3,4,5,12

Mapping of Sustainable Development Goals (SDGs) and Indian Knowledge System (IKS)

SDG No. & Title	Indian Knowledge System (IKS) Perspective
SDG 8 – Decent Work & Economic Growth	Historical Indian craftsmanship (*Shilpashastra*, artisan guilds) emphasized systematic design, planning, and quality assurance in product creation.
SDG 9 – Industry, Innovation & Infrastructure	Ancient engineering knowledge (*Yantras*, water-lifting machines, mechanical automata) reflects multidisciplinary integration in design and fabrication.
SDG 12 – Responsible Consumption & Production	Traditional Indian manufacturing practices focused on minimal material wastage and product longevity, e.g., sustainable construction of tools and machinery.
SDG 13 – Climate Action	Ancient practices like passive cooling, water harvesting, and natural ventilation in buildings demonstrate environmentally conscious design.
SDG 17 – Partnerships for the Goals	Traditional knowledge-sharing through *Guru-Shishya Parampara* promoted collaboration, mentorship, and interdisciplinary learning.

TEXT BOOKS:

1. Karl T Ulrich and Stephen D Eppinger, "Product Design and Development", Tata McGraw Hill, Fifth Edition, 2011.
2. John W Newstorm and Keith Davis, "Organizational Behavior", Tata McGraw Hill, Eleventh Edition, 2005.

REFERENCE BOOKS:

1. Hiriyappa B, “Corporate Strategy–Managing the Business”, Author House, 2013.
2. Mark S Sanders and Ernest J McCormick, "Human Factors in Engineering and Design", McGraw Hill Education, Seventh Edition, 2013
3. Peter F Drucker, “People and Performance”, Butterworth–Heinemann [Elsevier], Oxford, 2004.
4. Vinod Kumar Garg and Venkita Krishnan N K, “Enterprise Resource Planning Concepts”, Second Edition, Prentice Hall, 2003.
5. Mark S Sanders and Ernest J McCormick, "Human Factors in Engineering and Design", McGraw Hill Education, Seventh Edition, 2013.

SKILLS:

- Global Trends Analysis and Product decision
- Product Development Methodologies and Management

- Mechanical, Electronics and Software Subsystems



Image Source Link :

https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.amazon.in%2FFoundation-Integrated-Development-University-Elective-IIIebook%2Fdp%2FB08N1K3RG9&psig=AOvVaw2DMFUiEifE8i7ACCPGs6S3&ust=1741479240821000&source=images&cd=vfe&opi=89978449&ved=0CBQQjRxqFwoTCOCX-O-Z-YsDFQAAAAAdAAAAABAE

Image file name: Foundation Skills In Integrated Product Development.

R22M.Tech. SE PROGRAM.

REVISED COURSE STRUCTURE – C22

Pre - Semester

Course Code	Title of the course	L	T	P	SL	C	Course type
22SAB101	Orientation Session	0	2	0	0	1	Binary graded
22AMB101	IT workshop and cyber security	0	0	2	0	1	Binary graded
	Total	**0**	**2**	**2**	**0**	**2**	

I Year I Semester

Course Code	Title of the course		L	T	P	SL	C	Course type
22SEB101	Theory of Elasticity and Plasticity		3	2	0	3	4	Professional Core
22SEB102	Design of Reinforced Concrete for Industrial Applications		2	2	2	2	4	Professional Core
22SEB103	Design and Behaviour of Pre-Engineered Building Systems		3	2	0	2	4	Professional Core
	Department Elective - 1		3	2	0	3	4	Elective
22SEB104	**Teaching Assistantship**		0	0	2	0	1	Binary graded
22ENB101	**Indian Knowledge System**		0	2	0	0	1	Binary graded
	Work-in-lieu of a course*						2	Elective & Floating Credit
	Sub Total		**11**	**10**	**4**	**11**	**20**	
	Add on course -1						3	
	Total		**11**	**10**	**4**	**11**	**23**	

I Year II Semester

Course Code	Title of the course	L	T	P	SL	C	Course type
22SEB105	Structural Dynamics	2	2	2	3	4	Professional Core
22SEB106	Finite Element Analysis of Structures	3	2	0	2	4	Professional Core
	Department Elective - 2	3	2	0	3	4	Elective
	Department Elective - 3	3	2	0	3	4	Elective
22MSB101	Research Methodology & IPR	1	2	0	1	2	Interdisciplinary
22SEB107	Interdepartmental Project	0	0	2	0	1	Project
22SEB108	Teaching Assistantship	0	0	2	0	1	Binary graded
	Sub Total	**12**	**10**	**6**	**12**	**20**	
	Add on course -2					3	
	Total	**12**	**10**	**6**	**12**	**23**	

II Year I Semester

Course Code	Title of the course	L	T	P	SL	C	Course type
22SEB201/ 22SEB202	Project/Internship	0	2	24	0	13	Project
	Sub Total	**0**	**2**	**24**	**0**	**13**	
	Add on course -3 (MOOCs Course)					3	
	Total	**0**	**2**	**24**	**0**	**16**	

II Year II Semester

Course Code	Title of the course	L	T	P	SL	C	Course type
22SEB203/ 22SEB204	Project/Internship	0	2	24	0	13	Project
	Sub Total	**0**	**2**	**24**	**0**	**13**	
	Add on course -4 (MOOCs Course)					3	
	Total	**0**	**2**	**24**	**0**	**16**	

Department Electives

Course Code	Title of the course	L	T	P	SL	C
22SEB801	Structural Optimisation	3	2	0	3	4
22SEB802	Earthquake Resistant Design of Structures	3	2	0	3	4
22SEB803	Advanced Concrete Technology	2	2	2	2	4
22SEB804	Bridge Engineering	3	2	0	3	4
22SEB805	Advance Foundation Engineering	3	2	0	3	4
22SEB806	Advanced Steel Structural Design	3	2	0	3	4
22SEB807	Repair and Rehabilitation of Structures	3	2	0	3	4

22SEB101 – THEORY OF ELASTICITY & PLASTICITY

Hours per week:

L	T	P	C
3	2	0	4

PREREQUISITE KNOWLEDGE: Engineering Mechanics, Strength of Materials & Mathematics.

COURSE DESCRIPTION AND OBJECTIVES:

The course Theory of Elasticity & Plasticity introduces the fundamental and advanced concepts of material behavior under elastic and plastic deformation. It covers stress–strain relationships, constitutive equations, compatibility conditions, and boundary conditions in both two and three dimensions, using tools such as tensor calculus, energy methods, and variational principles to analyze engineering problems. Students will develop the ability to apply mathematical formulations to solve elasticity and plasticity problems, evaluate axisymmetric and plane stress/strain conditions, and analyze yielding, flow rules, and hardening mechanisms in materials. The course aims to equip learners with strong analytical skills for stress–strain evaluation, structural analysis, and material behavior prediction in mechanical, structural, and aerospace engineering applications.

MODULE-1

18L+12T+0P=30Hours

UNIT-1

INTRODUCTION TO THE MATHEMATICAL THEORY OF ELASTICITY:

Elasticity, stress, strain, Hooke's law; two-dimensional idealizations – plane stress and plane strain problems; equations of equilibrium, strain–displacement relations, constitutive relations, compatibility conditions, displacement and traction boundary conditions.

UNIT-2

TWO-DIMENSIONAL ELASTICITY PROBLEMS

Two-dimensional problems in rectangular coordinates – stress function, solution by polynomials, Saint Venant's principle, bending of a cantilever, determination of displacements; two-dimensional problems in polar coordinates – general equations, problems of axisymmetric stress distribution, pure bending of curved bars, effect of circular hole on stress distribution in plates, concentrated force at a point on a straight boundary.

PRACTICES:

- Calculate stress and strain for a rectangular plate under uniaxial tension using Hooke's law and strain–displacement relations.
- Determine compatibility conditions for a given two-dimensional strain field.
- Derive the stress function for a cantilever beam using Saint Venant's principle.
- Analyse stress concentration due to a circular hole in a plate using analytical equations.
- Evaluate axisymmetric stress distribution in a curved bar under bending using theoretical equations.

MODULE-2

27L+18T+0P=45 Hours

UNIT-1:
INTRODUCTION TO CARTESIAN TENSORS

Transformation laws of Cartesian tensors, special tensors and tensor operations, the Kronecker's delta, the permutation tensor, the e-d identity, symmetry and skew-symmetry, contraction, derivatives and the comma notation, Gauss' theorem, the base vectors and some special vector operations.

UNIT-2:
ADVANCED CARTESIAN TENSOR APPLICATIONS

Eigenvalue problem of a symmetric second order tensor; equations of elasticity using index notation; stress-strain problems in three dimensions – principal stresses, principal strains, three-dimensional problems.

UNIT-3:
ENERGY THEOREMS AND VARIATIONAL PRINCIPLES OF ELASTICITY

Strain energy and complementary energy, Clapeyron's theorem, virtual work and potential energy principles, principle of complementary potential energy, Betti's reciprocal theorem, principle of linear superposition, uniqueness of elasticity solution.

PRACTICES:

- Verify transformation laws of Cartesian tensors by transforming a second-order stress tensor from one coordinate system to another and checking invariance of principal values.
- Compute tensor operations such as contraction, symmetry check, and permutation tensor application for given sample tensors, including verification of the e–d identity.
- Solve the eigenvalue problem for a symmetric second-order stress tensor and determine principal stresses and directions.
- Apply Clapeyron's theorem to calculate strain energy stored in a loaded beam and compare with results from direct deflection calculations.
- Demonstrate Betti's reciprocal theorem by analyzing two different loading cases on the same elastic body and verifying equality of work done.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Mapping with POs	Mapping with PSOs
1.	Apply the fundamental concepts of elasticity to determine stress, strain, and displacement fields in two-dimensional problems.	Apply	1 & 2	1
2.	Apply energy theorems, variation principles, and reciprocal theorems to solve elasticity problems.	Apply	1, 2 & 4	1

3.	Solve plane stress and plane strain problems using analytical methods such as stress functions and polynomial solutions.	Analyze	1, 2, 3 & 4	1, 2
4.	Analyze Cartesian tensor transformations, tensor operations, and their applications in elasticity problems.	Analyze	1, 2, 3 & 4	1, 2
5.	Determine principal stresses and strains in three-dimensional problems using index notation and eigenvalue methods.	Evaluate	1, 2, 3 & 4	1, 2

MAPPING OF SUSTAINABLE DEVELOPMENT GOALS:



TEXT BOOKS:

1. Martin H. Sadd "Elasticity: Theory, Applications, and Numerics", Elsevier publishing, 5th edition, 2022.
2. Timoshenko, S.P. and Goodier, J.N., Theory of Elasticity, Mc Graw Hill, Singapore, 1982.

REFERENCEBOOKS:

1. Chakrabarty, J, Theory of Plasticity, Elsevier, London, 2006.
2. Ameen, M., Computational Elasticity–Theory of Elasticity, Finite and Boundary Element Methods, Narosa Publishing House, 2004.
3. Srinath, L.S., Advanced Mechanics of Solids, Second Edition, Tata McGraw Hill, India, 2003.
4. Hill, R., Mathematical Theory of Plasticity, Oxford University Press, 1998.
5. Chen, W.F., and Han, D.J., Plasticity for Structural Engineers, Springer Verlag, 1998.

SKILLS:

- ✓ Ability to evaluate and interpret stress and strain states in engineering components under various loading conditions.
- ✓ Proficiency in applying Cartesian tensor operations and transformations in mechanics problems.
- ✓ Capability to derive and solve elasticity problems using equations of equilibrium, compatibility, and constitutive relations.
- ✓ Skill in using energy theorems and variational principles for solving structural and elasticity problems.
- ✓ Competence in solving plane stress/strain and axisymmetric problems in both rectangular and polar coordinates.

Image source: Syllabus reorganization request

Image file name: Theory of Elasticity & Plasticity

22SEB102 -DESIGN OF REINFORCED CONCRETE FOR INDUSTRIAL APPLICATIONS

Hours Per Week :

L	T	P	C
2	2	2	4

PREREQUISITE KNOWLEDGE:
Strength of Materials, Structural Analysis, Basic RCC Design (IS 456:2016).

COURSE DESCRIPTION & OBJECTIVES:

This course equips students with the knowledge and skills to design and detail reinforced concrete structural elements for industrial structures such as factory buildings, heavy machine foundations, storage structures, silos, bunkers, industrial floors, and special RCC systems. Emphasis is placed on limit state design, serviceability requirements, and seismic and dynamic considerations relevant to industrial environments. The course also integrates software-based design and detailing using STAAD. Pro, ETABS, and AutoCAD.

MODULE-1

18L+0T+12P = 30hours

UNIT-1:
DESIGN PHILOSOPHIES FOR INDUSTRIAL RCC

Review of concrete materials for industrial exposure (chemical, thermal, abrasion resistance), Limit State Design principles as per IS 456, IS 3370, IS 800 (RCC parts), IS 875 (industrial loadings), Working Stress Method vs Limit State Method in industrial contexts, Stress-strain behavior under cyclic and dynamic loads, Overview of fire-resistant concrete design

UNIT-2:

INDUSTRIAL LOADS AND STRUCTURAL BEHAVIOUR

Classification of industrial loads: dead, live, crane loads, impact, vibration, thermal, wind, seismic (IS 875, IS 1893, IS 800), Load combinations specific to industrial buildings and equipment foundations, Stress concentrations and fatigue in industrial structures.

PRACTICES:

- STAAD.Pro modeling of an industrial shed with crane girder
- Detailing of Raft and pile foundations for industrial buildings
- AutoCAD detailing of heavy beam and column connections.

MODULE-2

27L+0T+18P= 45hours

UNIT-1:

HEAVY-DUTY BEAMS, SLABS, AND INDUSTRIAL FLOORS
Design of heavy-duty beams and girders for concentrated loads and crane girders, Design of industrial slabs: machine foundations, elevated slabs, flat slabs, Serviceability: deflection, crack control, vibration limits

UNIT-2:
RCC COLUMNS AND FOUNDATIONS IN INDUSTRIAL CONTEXTS

Short and long columns under biaxial bending (IS 456, SP-16), Pedestals and machine foundation blocks (IS 2974), Pile foundations and raft foundations for industrial loading.

UNIT-3:
STORAGE AND CONTAINMENT STRUCTURES AND SPECIAL CONSIDERATIONS

Design of silos, bunkers, and bins (IS 4995), Water retaining and chemical storage tanks (IS 3370), Design for thermal and chemical stresses. Blast-resistant and fire-resistant design concepts, Seismic detailing for industrial RCC structures (IS 13920, IS 1893-Part 4), Retrofitting of industrial RCC members

PRACTICES:

- ETABS/STAAD model of a multi-bay industrial building under seismic loading
- AutoCAD detailing of silo reinforcement layout.
- Seismic detailing for industrial RCC structures (IS 13920)

COURSE OUTCOMES:

Upon successful completion of this course, students will be able to:

CO No.	Course Outcomes	Bloom's Level	Mapping with POs
1	Apply IS codes and advanced design principles to industrial RCC structures.	Apply	1,2,3,5
2	Analyze industrial loads and design RCC members for heavy-duty applications.	Analyse	1,2,3,4.5
3	Design and detail industrial slabs, beams, columns, and foundations using software tools.	Analyse	1,2,3,5,12
4	Integrate seismic and fire safety considerations in industrial RCC design.	Evaluate	1,2,3,4,5,11
5	Develop structural solutions for special industrial RCC structures such as silos and tanks.	Create	1,23,3,4,6,11

TEXT BOOK:

1. P.C. Varghese – Advanced Reinforced Concrete Design, PHI Learning.
2. N. Krishna Raju – Advanced Reinforced Concrete Design, CBS Publishers.
3. Devdas Menon & Unnikrishna Pillai – Reinforced Concrete Design, Tata McGraw Hill.

REFERENCE BOOKS:

1. IS 456:2016 – Code of Practice for Plain and Reinforced Concrete
2. IS 875 (Parts 1–5) – Code of Practice for Design Loads
3. IS 4995 – Design of Bins and Silos
4. IS 3370 – Concrete Structures for Storage of Liquids
5. IS 2974 – Design of Machine Foundations
6. SP-16 – Design Aids for Reinforced Concrete to IS 456
7. IIT Madras / NIT Tiruchirappalli RCC Industrial Design course notes.

SKILLS:

- ✓ Interpret and apply IS 456, IS 875, IS 1893, IS 2974, IS 3370, IS 4995 for industrial RCC design.
- ✓ Analyze industrial loading scenarios including dynamic, impact, crane, and thermal loads.
- ✓ Develop structural solutions that meet seismic, fire safety, and durability requirements.

22SEB103 – DESIGN AND BEHAVIOUR OF PRE-ENGINEERED BUILDING SYSTEMS

HOURS PER WEEK:

L	T	P	C
3	2	0	4

PREREQUISITE KNOWLEDGE:
Structural analysis, Design of steel structures, strength of materials, modern approaches in pre-engineered building systems.

COURSE DESCRIPTION AND OBJECTIVES:
This course provides an in-depth exploration of Pre-Engineered Building (PEB) systems, addressing their fundamental elements, load considerations, and structural design principles. It delves into the design of primary and secondary PEB components, including main frames, bracing, mezzanine systems, and crane beams, using modern analysis and modeling techniques. The course integrates code-based design methods (IS, AISC, MBMA), focuses on stability and optimization strategies, and emphasizes the practical application of structural design software. It also examines cost considerations, sustainable practices, and the relevance of Indigenous Knowledge Systems (IKS) in modern construction. Through a blend of theoretical instruction and hands-on practices, students will develop the ability to design and evaluate safe, economical, and environmentally responsible PEB solutions.

MODULE-1

12L+0T+12P=24 Hours

UNIT-1:

BACKGORUND ON PRE-ENGINEERED BUILDINGS

PEB Elements: – Elements of PEB, Primary materials and prefabricated component used manufacturing of PEB. Main frames, Secondary frame system: Sizes and Properties of Purlins & Girts – Bracing System, Sheeting and Cladding: Roof Sheeting and Wall sheeting. **Stability of PEB-** Shear buckling effect (d/t ratio exceeding 67ε), Effective Cross-sectional area concept for Compression Members d/t ratio exceeding 42ε; Effect of d/t ratio for flexural members according to section classifications, Lateral Torsional Restraint system: Flange Bracing and design considerations.

UNIT-2:

CRANE SYSTEM IN PEB

CRANES- Different types of Cranes – EOT Cranes, Monorail Cranes, Underslung and Wall mounted - Design of Crane beams with and Without Top Channels (Surge Beam), Design of Crane Brackets – Frame design with different types of Cranes using software.

PRACTICES:

- Determination of size and properties of purlins and girts for various spans and loads.
- Study of bracing systems: tension-only bracing vs. rigid bracing.
- Calculation of shear buckling effect for thin-walled sections (d/t ratio > 67ε).

- Calculation of effective cross-sectional area for compression members (d/t ratio > 42ε).
- Determination of section classification for flexural members as per IS 800.
- Design of lateral-torsional restraint system (flange bracing) for main frames.
- Selection of roof sheeting and wall sheeting profiles based on load and span requirements.
- Comparison of material costs for different sheeting and cladding systems.
- Calculation of vertical and horizontal loads due to crane operation (impact, surge, lateral loads).
- Design of crane beams (with and without top channel surge beam) as per IS 800.
- Calculation of wheel loads and load transfer mechanisms to crane brackets.
- Design of crane brackets for different crane loads and spans.

MODULE-2

18L+0T+18P=36 Hours

UNIT-1:
DESIGN OF MEZZANINE STRUCTURES

Mezzanine- Design of Mezzanine Beams, Columns and joists – Mezzanine decking, Different types of Mezzanine Floor systems – Grating, Chequered plate and Rigid floor System

UNIT-2:
DESIGN OF BASE PLATE CONNECTIONS

Base Plate: Types of base plate Pinned, Fixed, strength bolts, different types of bolts & grades, Lever arm, bolt Patten its effect on connection design, thickness of connection plate, base plate size, Selection of governing forces for base connection design & Anchor bolt.

UNIT-3: ANALYSIS AND DESIGN OF PRE-ENGINEERED BUILDINGS

2D and 3D Modelling of Portal Frames, Optimization Techniques, Comparison of software output with manual calculations. Design of Cold Formed Sections i.e., Purlins and Girts, Design of Roof Sheeting, trapezoidal, Standing seam sheeting, Welding technology, Manufacturing process, Erection Procedures.

PRACTICES:

- Calculation of design loads on mezzanine floors (dead load, live load, equipment loads).
- Design of mezzanine beams, columns, and joists using IS 800.
- Comparison of different mezzanine floor systems based on cost and load-carrying capacity.
- Identification of different types of base plates (pinned, fixed) and understanding their applications.
- Selection of bolt grades and types for base plate connections as per IS 3757 and IS 800.
- 2D modeling of a portal frame in structural analysis software (SAP2000/STAAD).
- 3D modeling of a complete PEB structure including main frames, secondary members, and bracing.
- Comparison of software output with manual calculations for critical members.
- Implementation of optimization techniques to reduce material usage while ensuring stability.
- Design of cold-formed sections (purlins and girts) based on span and loading requirements.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Mapping with POs
1.	Identify and describe the primary and secondary elements of PEB, including stability considerations and component interactions.	Apply	1, 2
2.	Analyze and evaluate the design considerations of lateral and torsional restraints, shear buckling, and effective cross-sectional areas for compression and flexural members in PEB systems.	Analyze	1, 2, 3
3.	Compute and design crane beam systems (with and without top channels) and crane brackets for different types of cranes used in PEB structures.	Analyze	1, 2, 3, 5
4.	Design mezzanine floor systems, including beams, columns, joists, and decking, while comparing various flooring system alternatives for cost and efficiency.	Apply	1, 2, 3, 11
5.	Select appropriate base plate connections considering bolt grades, patterns, lever arms, and base plate design criteria for different structural conditions.	Apply	1, 2, 3, 5
6.	Develop 2D and 3D structural models of PEB systems, apply optimization techniques, and compare software outputs with manual design calculations.	Create	1, 2, 3, 5, 9, 11

MAPPING OF SUSTAINABLE DEVELOPMENT GOALS AND INDIAN KNOWLEDGE SYSTEM:



TEXT BOOKS:

1. Pre-Engineered Steel Building, K.S. Vivek and P.Vyshnavi, LAP Lamdert Academic Publishing.
2. Metal building systems: Design and Specifications, Third edition, Alexander Newman, McGraw- Hill Education.
3. McCormac, J. C., & Csernak, S. F. (2015). Structural Steel Design: LRFD and ASD (6th ed.). Pearson Education.

REFERENCEBOOKS:

8. Duggal. S. K, ―Limit State Design of Steel Structures‖, Tata McGraw-Hill Education Publishers, 3rd edition, 2017.
9. Metal Building Manufacturers Association (MBMA). (2018). Metal Building Systems Manual. MBMA Publications.
10. American Institute of Steel Construction (AISC). (2017). Steel Construction Manual (15th ed.). AISC.

SKILLS:

- ✓ Structural load calculation
- ✓ Rigid frame analysis
- ✓ Connection design
- ✓ Code-based structural design (IS, AISC, MBMA)
- ✓ Section optimization
- ✓ Component identification and detailing
- ✓ Structural design software application
- ✓ Cost and efficiency evaluation
- ✓ Sustainable design integration
- ✓ Technical documentation preparation

22SEB105- STRUCTURAL DYNAMICS

Hours Per Week :

L	T	P	C
2	2	2	4

PREREQUISITE KNOWLEDGE:
Structural Analysis I, Structural Analysis II, Design of Concrete Structures and Design of Steel Structures

COURSE DESCRIPTION & OBJECTIVES:
The objective is to provide the fundamental understanding of the structural dynamics. The problem solving ability for dynamic response in civil engineering design, analysis and research. Introduce students to analytical and numerical methods in structural dynamics with emphasis on vibration. To provide opportunities to optimize system for desired dynamic response. To provide the basic framework for studying time-dependent response of mechanical

MODULE-1

18L+0T+12P= 30 hours

UNIT-1:
SINGLE DEGREE OF FREEDOM SYSTEMS
Introduction, Mathematical modelling, Equation of Motions, Solution methods of single degree of freedom systems (SDOF), Springs combination- series, parallel, inclined, Natural Frequency and Time Period.

UNIT-2:

FREE AND FORCED VIBRATION OF SDOF SYSTEM
Free vibration of undamped and damped system, Forced vibration of damped and undamped System – Response to harmonic forces- Half Power Bandwidth and periodic forces - Fourier Series, Duhamel Integrals.

PRACTICES:

- Calculate the stiffness of springs in parallel and in series.
- Calculate the Natural Frequency and Time Period.
- Calculate the Free and Forced Vibrations of SDOF Systems.
- Determine the response spectrum Analysis.
- Determine the Half Power Bandwidth and Periodic Forces.

MODULE-2

27L+0T+18P= 45 hours

UNIT-1:

TWO DEGREES OF FREEDOM SYSTEMS

Introduction, Concept of Shear Building, Free Vibrations of damped and undamped system, Forced Vibrations of damped and undamped system, Natural Frequencies and Mode Shapes.

UNIT-2: MULTI DEGREE OF FREEDOM SYSTEMS

Multiple degree of freedom systems (Three degrees of freedom system) - Introduction, free vibration analysis and forced vibration analysis, undamped systems, damped systems, Natural Frequencies and Normal Modes.

UNIT-3: SOLUTION OF STRUCTURAL ELEMENTS

Solution of beams and frames, machine foundation, Introduction to Random vibration.

PRACTICES:

- Calculate Free vibrations of damped and Undamped System for MDOF.
- Calculate Forced Vibrations of damped and Undamped system for MDOF.
- Calculate the Natural Frequencies of Two and MDOF Systems.
- Calculate the Modes of Different Systems.
- Calculate the Mode Shapes of Different Systems.

COURSE OUTCOMES:

Upon successful completion of this course, students will be able to:

CO No.	Course Outcomes	Bloom's Level	Mapping with POs
1	Apply the equation of motion for single degree of freedom systems.	Apply	1, 2, 3
2	Analyse the concepts of Springs combination.	Analyse	1, 2, 3
3	Evaluate the impact of damping on characteristics of vibrating system.	Evaluate	1, 2, 3
4	Evaluate the dynamic behaviour of Multi degree of freedom	Evaluate	1, 2, 3
5	Create the dynamic system with various degree of freedom.	Create	1, 2, 3

MAPPING OF SUSTAINABLE DEVELOPMENT GOALS AND INDIAN KNOWLEDGE SYSTEM:



TEXT BOOK:

1. Mario Paz and Leigh; ―Structural dynamics‖, CBS Publishers, 5th edition 2018.
2. Anil K Chopra, ―Dynamics of structures‖; Prentice-Hall of India Limited, New Delhi.5th edition 2017.

REFERENCE BOOKS:

1. S.R Damodarasamy and S. Kavitha, ―Basics of Structural Dynamics and Aseismic Design‖ PHI Learning 2018.
2. G. C. Hart & K. Wang; ―Structural Dynamics for Structural Engineers‖, John Wiley & Sons.1st edition 1991.
3. R.W. Clough and P.E. Penzien, ―Dynamics of Structures (Theory and applications to structural engineering), McGraw-Hill. 1st edition, 1975.

SKILLS:

- ✓ understanding structural behavior under dynamic loads
- ✓ applying knowledge of vibrations, natural frequencies, and damping
- ✓ applying analytical techniques to solve structural dynamics problem
- ✓ applying numerical techniques to solve structural dynamics problem

22SEB106– FINITE ELEMENT ANALYSIS OF STRUCTURES

Hours per week:

L	T	P	C
3	2	0	4

PREREQUISITE KNOWLEDGE:
Structural Analysis, Mechanics of Solids, and Matrix Methods.

COURSE DESCRIPTION AND OBJECTIVES:
This course introduces the finite element method (FEM) for structural analysis. It covers variational formulations, element discretization, development of stiffness matrices, isoparametric formulation, and applications to structural and solid mechanics problems. The objective is to enable students to model structural systems using finite elements, derive governing equations, and solve real-life engineering problems involving trusses, beams, frames, plates, and axisymmetric structures.

MODULE-1

18L+12T+0P=30 Hours

UNIT-1:

INTRODUCTION AND METHODS OF STRUCTURAL ANALYSIS
Background and general description of the method – Applications, Review of various classical methods of Structural analysis- Matrix methods- Stiffness and Flexibility methods.

UNIT-2:

THEORY OF FINITE ELEMENT METHOD
Variational method-Discretization concept- Concept of element –various elements shapes – displacement models – Convergence- shape functions.

PRACTICES:

- Compare solutions of a simple beam using classical, matrix, and FEM approaches.
- Perform manual discretisation of a truss into finite elements.
- Develop shape functions for a 1D bar element.
- Verify convergence by refining mesh in a bar element problem.

MODULE-2

27L+18T+0P=45 Hours

UNIT-1:

FINITE ELEMENT FORMULATION
Development of shape functions for different elements-Spring-Truss-BeamPlane elements-Plane stress and plane strain-Assemblage of elements construction of stiffness matrix and loads – boundary conditions –patch test-solution of overall problem.

UNIT-2:

ISOPARAMETRIC FORMULATION

Determination of lateral forces using equivalent static method and modal analysis – Load combinations as per IS 1893 (Part 1) – Analysis of intermediate frame – Design and detailing of typical flexural member, column, footing – Detailing of exterior joint as per IS 13920.

UNIT-3:

APPLICATIONS TO STRUCTURAL AND SOLID MECHANICS Concept of Isoperimetric element – One and Two dimensional elements. Natural coordinates- Development of Higher order elements- Lagrange –Serendipity –Interpolation formulation of element stiffness and loads.

PRACTICES:

1. Develop stiffness matrices for spring, truss, and beam elements manually.
2. Assemble element stiffness matrices for a 2D truss structure.
3. Perform patch test on a rectangular element.
4. Implement isoperimetric formulation for a quadrilateral element.
5. Analyze a simply supported beam using FEM and compare with classical solution.
6. Model and solve a 2D frame using FEM software.
7. Analyze axisymmetric problems (cylindrical pressure vessels, domes).
8. Perform FEM analysis of a plate using higher-order elements.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcome	Blooms Level	Mapping with POs	Mapping with PSOs
1	Explain the fundamentals, applications, and need for FEM in structural analysis.	Understanding	1, 2	1
2	Apply matrix methods and FEM concepts to discretize and model structures.	Applying	1, 2, 3	1, 2
3	Derive and develop element stiffness matrices and shape functions.	Analyzing	1, 2, 3, 4	1, 2
4	Apply isoperimetric formulation to 1D and 2D elements.	Evaluating	1, 2, 3, 4	1, 2
5	Solve real-world problems in trusses, beams, frames, plates, and axisymmetric structures using FEM.	Creating	1, 2, 3, 4	1, 2

MAPPING OF SUSTAINABLE DEVELOPMENT GOALS AND INDIAN KNOWLEDGE SYSTEM:



Text Books:

1. C. S. Krishnamoorthy, Finite Element Analysis: Theory and Programming, Tata McGraw-Hill, 1994.
2. J. N. Reddy, An Introduction to the Finite Element Method, McGraw Hill, 4th Edition, 2019.
3. O. C. Zienkiewicz, R. L. Taylor, and J. Z. Zhu, The Finite Element Method: Its Basis and Fundamentals, Butterworth-Heinemann, 7th Edition, 2013.

Reference Books:

1. K. J. Bathe, Finite Element Procedures, Prentice Hall, 2006.
2. R. D. Cook, D. S. Malkus, M. E. Plesha, and R. J. Witt, Concepts and Applications of Finite Element Analysis, Wiley, 2001.
3. Daryl L. Logan, A First Course in the Finite Element Method, Cengage Learning, 6th Edition, 2015.

SKILLS:

After successful completion of this course, students will have the ability to:

- ✓ discretize structures into finite elements and select suitable element types.
- ✓ Develop and implement shape functions for 1D and 2D elements.
- ✓ Assemble global stiffness matrices and apply boundary conditions.
- ✓ Use isoperimetric formulation for higher-order elements.
- ✓ Perform FEM analysis for trusses, beams, frames, plates, and axisymmetric problems.
- ✓ Validate FEM results through patch tests and comparison with classical methods.
- ✓ Apply FEM software tools for real-world structural engineering problems.

Image source: https://www.blog.jf.ag/wp-content/uploads/2022/01/Role-of-Finite-Element-Analysis-in-Enhancing-Structural-Integrity-688x360.png

Image file name: Finite element analysis for structures

22SEB801 – STRUCTURAL OPTIMIZATION

Hours per week:

L	T	P	C
3	2	0	4

PREREQUISITE KNOWLEDGE:
Engineering Mechanics, Structural Analysis & basic computer programming.

COURSE DESCRIPTION AND OBJECTIVES:
This course covers unconstrained and constrained optimization techniques for single and multivariable problems, direct and gradient-based methods, and applications in civil and structural engineering. Students will learn classical analytical methods, modern numerical techniques, and computational tools for practical design optimization. This course aims to develop students' ability to formulate and solve structural optimization problems using analytical, numerical, and computational methods. It focuses on applying direct and gradient-based techniques to real-world structural designs, enhancing problem-solving skills, resource efficiency, and sustainable engineering practices.

MODULE-1

18L+12T+0P=30 Hours

UNIT-1:
INTRODUCTION TO STRUCTURAL OPTIMISATION
Concept of structural optimization – scope and significance – problem formulation: design variables, objective function, constraints, types of problems – optimality criteria for single and multivariable problems – examples of structural engineering applications.

UNIT-2:
SINGLE VARIABLE UNCONSTRAINED OPTIMIZATION
Bracketing methods: unrestricted search, exhaustive search – region elimination methods: interval halving, dichotomous search, Fibonacci method, golden section method – interpolation methods: quadratic interpolation, cubic interpolation – gradient-based methods: Newton–Raphson, secant, bisection methods.

PRACTICES:
- Identify and formulate three real-world structural optimization problems with defined design variables, objective functions, and constraints.
- For given single-variable functions, determine optimality using first and second derivative tests.
- Solve at least two optimization problems using unrestricted search and exhaustive search methods.
- Apply interval halving and golden section search to find the optimum of a given function and compare the number of iterations.
- Implement quadratic interpolation and Newton–Raphson methods in MATLAB/Python for given functions.

MODULE-2

27L+18T+0P=45Hours

UNIT-1:
MULTI-VARIABLE UNCONSTRAINED OPTIMISATION
Optimality criteria – unidirectional search – direct search methods: random search, grid search, univariate method, Hooke & Jeeves' pattern search, Powell's conjugate direction method, simplex method – gradient-based methods: steepest descent (Cauchy) method, conjugate gradient (Fletcher–Reeves) method, Newton's method, variable metric methods (DFP, BFGS).

UNIT-2:
CONSTRAINED OPTIMIZATION TECHNIQUES
Classical methods: direct substitution, constrained variation, method of Lagrange multipliers, Kuhn–Tucker conditions – linear programming problem: standard form, simplex method – indirect methods: elimination of constraints, transformation techniques, penalty function method.

UNIT-3:
ADVANCED CONSTRAINED OPTIMIZATION AND APPLICATIONS
Direct methods: Zoutendijk's method of feasible directions, Rosen's gradient projection method – applications in truss, beam, and frame optimization – use of computational tools – case studies in structural engineering design.

PRACTICES:

- Write MATLAB/Python code for the steepest descent and conjugate gradient methods for multivariable problems.
- Solve the same constrained optimization problem using the Lagrange multiplier method, penalty function method, and Rosen's gradient projection method, then compare results.
- Select a real truss or beam design and optimize it for minimum weight using any suitable method.
- Use an optimization toolbox (MATLAB, Excel Solver, or Python libraries) to solve a multivariable constrained structural optimization problem.
- Develop a mini-project integrating at least two optimization techniques for an actual civil engineering component, documenting methodology and results.

COURSE OUTCOMES:
Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Mapping with POs	Mapping with PSOs
1.	Fundamental concepts, scope, and formulation of structural optimization problems in engineering design.	Apply	1	1
2.	Apply single-variable optimization techniques to engineering problems.	Apply	1, 2	1, 2
3.	Implement multi-variable unconstrained optimization methods for structural design.	Analyze	1, 2, 3 & 4	1, 2

4.	Solve constrained optimization problems using classical, direct, and indirect methods.	Evaluate	1, 2, 3 & 4	1, 2
5.	Integrate computational tools and optimization techniques in real structural engineering applications.	Create	1, 2, 3 & 4	1, 2

MAPPING OF SUSTAINABLE DEVELOPMENT GOALS AND INDIAN KNOWLEDGE SYSTEM:



TEXT BOOKS:

- Arora J. S., Introduction to Optimum Design, Fourth edition, Academic Press Inc., 2016.
- Deb, K.., Optimization for Engineering Design – Algorithms and Examples, Second edition, PHI Learning Pvt. Ltd., New Delhi, 2012.

REFERENCEBOOKS:

- Rao S. S., Engineering Optimization – Theory and Practice, John Wiley & Sons, Inc., New Jersey, 2009.
- Spillers, W.R., and MacBain, K.M., Structural Optimization, Springer, New York, 2009.
- Christensen, P.W., and Klarbring, A., An Introduction to Structural Optimization, Springer, New York, 2009.

SKILLS:

- ✓ Optimization Problem Formulation.
- ✓ Application of Numerical Methods.
- ✓ Computational Tool Utilization
- ✓ Efficient Structural Design

Image source: https://www.researchgate.net/figure/The-three-categories-of-structural-optimisation-a-sizing-optimisation-of-a-truss_fig22_267451070

Image file name: Structural Optimization

22SEB802 – EARTHQUAKE RESISTANT DESIGN OF STRUCTURES

Hours per week:

L	T	P	C
3	2	0	4

PREREQUISITE KNOWLEDGE:

Structural Analysis & Structural Dynamics.

COURSE DESCRIPTION AND OBJECTIVES:

This course provides an in-depth understanding of the concepts, principles, and practices for designing earthquake-resistant structures in compliance with Indian Standards. It covers seismic behaviour of buildings, lateral load resisting systems, ductility considerations, design procedures, and detailing requirements. The objective of this course is to equip students with the knowledge and skills to design earthquake-resistant buildings by understanding seismic forces, structural response, ductility requirements, and detailing provisions as per IS codes. It aims to develop proficiency in selecting appropriate lateral load resisting systems, analyzing structures using static and dynamic methods, applying code-based ductility criteria, and exploring advanced seismic protection strategies like base isolation.

MODULE-1

18L+12T+0P=30Hours

UNIT-1:

SEISMIC-RESISTANT BUILDING ARCHITECTURE

Introduction – Lateral load resisting systems: moment resisting frame, shear wall/bearing wall system, dual system – Building configuration: common problems and solutions – Building characteristics: mode shapes, fundamental period, building frequency vs ground period, damping, ductility, seismic weight, redundancy, non-structural elements, soil liquefaction – Foundations – Quality of construction and materials: concrete quality, joints, general detailing requirements.

UNIT-2:

DESIGN FORCES FOR BUILDINGS

Introduction – Equivalent static method – Mode superposition technique – Dynamic inelastic time history analysis – Advantages and limitations – Determination of lateral forces as per IS 1893 (Part 1): equivalent static method, modal analysis using response spectrum.

PRACTICES:

- Identify lateral load resisting systems in at least five existing buildings with sketches and classification.
- Analyse two building configurations and suggest modifications to improve seismic performance.
- Calculate fundamental period and mode shapes for a given RC frame using theoretical formulas.
- Compute lateral forces for a simple building model using the equivalent static method as per IS 1893.
- Compare results from equivalent static method and modal response spectrum method for the same building.

MODULE-2

27L+18T+0P=45Hours

UNIT-1:

DUCTILITY CONSIDERATIONS IN EARTHQUAKE RESISTANT DESIGN OF RCC BUILDINGS

Impact and importance of ductility – Requirements for ductility – Assessment: member and structural ductility – Factors affecting ductility – Ductility factors – IS 13920 ductility provisions.

UNIT-2:

EARTHQUAKE RESISTANT DESIGN OF A TWO-STOREY, TWO-BAY RCC BUILDING

Determination of lateral forces using equivalent static method and modal analysis – Load combinations as per IS 1893 (Part 1) – Analysis of intermediate frame – Design and detailing of typical flexural member, column, footing – Detailing of exterior joint as per IS 13920.

UNIT-3: BASE ISOLATION OF STRUCTURES

Introduction to seismic isolation – Considerations and basic elements – Seismic isolation design principles – Feasibility and configurations – Application examples in building design.

PRACTICES:

- Calculate ductility factors for a given RC member and compare with IS 13920 provisions.
- Design and detail a column and beam for given seismic forces ensuring ductility requirements.
- Prepare a complete reinforcement detailing for an exterior beam-column joint as per IS 13920.
- Perform a step-by-step design for a two-storey RC frame subjected to seismic loads using IS 1893.
- Develop a conceptual base isolation layout for a medium-rise building with sketches and material suggestions.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Mapping with POs	Mapping with PSOs
1.	Principles of seismic-resistant building architecture and code-based provisions.	Apply	1, 2	1
2.	Apply ductility provisions and assess member/structural ductility for RCC buildings.	Apply	1, 2, 3 & 4	1, 2
3.	Determine seismic design forces using equivalent static and dynamic methods as per IS 1893.	Evaluate	1, 2, 3 & 4	1, 2

4.	Design and detail RCC members, joints, and foundations for earthquake resistance as per IS 13920.	Create	1, 2, 3 & 4	1, 2
5.	Propose advanced seismic protection systems including base isolation for enhanced structural performance.	Create	1, 2, 3 & 4	1, 2

MAPPING OF SUSTAINABLE DEVELOPMENT GOALS AND INDIAN KNOWLEDGE SYSTEM:



TEXT BOOKS:

1. Chopra, Anil K. – Dynamics of Structures: Theory and Applications to Earthquake Engineering, Pearson, 2023.
2. Agarwal, Pankaj, and Shrikhande, Manish – Earthquake Resistant Design of Structures, PHI Learning, 2022.

REFERENCEBOOKS:

3. IS 1893 (Part 1): 2016 – Criteria for Earthquake Resistant Design of Structures.
4. IS 13920: 2016 – Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces.

SKILLS:

- ✓ Ability to determine design forces and assess building response.
- ✓ Competence in detailing RCC members and joints for earthquake resistance.
- ✓ Proficiency in applying IS 1893 and IS 13920 for structural design.
- ✓ Capability to integrate base isolation and advanced seismic technologies.

Image source: https://www.linkedin.com/pulse/guidelines-earthquake-resistant-design-structures-india-g-k-wbrpc

Image file name: Earthquake Resistant Design of Structures

22SEB803 – ADVANCED CONCRETE TECHNOLOGY

Hours per week:

L	T	P	C
2	2	2	4

PREREQUISITE KNOWLEDGE:
Basic knowledge of cement, concrete technology, and Building Materials.

COURSE DESCRIPTION AND OBJECTIVES:
This course provides an in-depth understanding of cement chemistry, hydration mechanisms, microstructure development, admixtures, and special concretes. It aims to build competence in analyzing the properties of hardened concrete, evaluating durability, applying non-destructive testing, and exploring recent advancements in concrete technology. The course equips students with the knowledge to design and use various special concrete techniques, such as high-performance, self-compacting, and fiber-reinforced concrete, while addressing future challenges in concrete mechanics and technology.

MODULE-1

18L+0T+12P=30 Hours

UNIT-1:

CEMENT CHEMISTRY
Portland cement and its constituent phases-High temperature chemistry-The chemistry of Portland cement manufacture-Hydration of calcium silicate phases-Hydrated aluminates, ferrite and sulphate phases- Hydration of cement-composite cements.

UNIT-2:

MICROSTRUCTURE AND PROPERTIES OF HARDENED CONCRETE
Microstructure of Concrete-Strength Dimensional Stability-Durability-Curing of Concrete-Humidity performances-NDT methods

PRACTICES:

- Study the hydration process of different cement phases through calorimetry.
- Prepare and analyze thin sections of hardened concrete under microscope.
- Conduct compressive, tensile, and flexural strength tests on concrete specimens.
- Perform durability tests such as sulphate attack and chloride penetration.
- Carry out rebound hammer and ultrasonic pulse velocity tests (NDT).
- Compare the curing efficiency of water curing vs membrane curing.

MODULE-2

27L+0T+18P=45 Hours

UNIT-1: ADMIXTURES IN CONCRETE
Different types of admixtures-mode of action and compatibility issues. Recent advances in concrete-Progress in concrete technology-Structural light weight concrete

UNIT-2:

SPECIAL CONCRETES:

High Performance Concrete-Self Compacting Concrete-Self Curing Concrete-Fiber reinforced Concrete-Ferro cement Advances in concrete Mechanics-Future challenges in concrete technology

UNIT-3:

SUSTAINABLE AND EMERGING CONCRETES

Supplementary cementitious materials (fly ash, slag, silica fume, metakaolin), Geopolymer concrete: principles, properties, and applications, Recycled aggregate concrete: challenges and benefits, 3D printed concrete and digital fabrication, Self-healing concrete: bacterial and chemical mechanisms, Low-carbon concrete technologies and their role in sustainable development

PRACTICES:

- Design a concrete mix incorporating chemical and mineral admixtures.
- Prepare self-compacting concrete and evaluate workability using L-box, V-funnel, and slump flow tests.
- Cast and test lightweight aggregate concrete specimens for compressive strength.
- Produce and evaluate fibre reinforced concrete for strength and crack resistance.
- Design and test ferrocement panels for load carrying capacity.
- Compare performance of conventional concrete vs high-performance concrete in terms of strength and durability.
- Prepare geopolymer concrete mix using fly ash/slag and evaluate strength.
- Perform recycled aggregate concrete tests and compare with conventional concrete.
- Case study on applications of 3D printed and self-healing concretes.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcome	Blooms Level	Mapping with POs	Mapping with PSOs
1	Explain cement chemistry and hydration mechanisms.	Understanding	1, 2	1
2	Evaluate microstructure and properties of hardened concrete using NDT methods.	Analyzing	1, 2, 3 & 4	1, 2
3	Assess the role and compatibility of admixtures in concrete.	Applying	1, 2, 3	1, 2
4	Design and test special concretes like HPC, SCC, and FRC.	Creating	1, 2, 3 & 4	1, 2
5	Discuss future challenges and advances in concrete technology.	Evaluating	1, 2, 4	1, 2

MAPPING OF SUSTAINABLE DEVELOPMENT GOALS AND INDIAN KNOWLEDGE SYSTEM:



Text Books:

- M. Neville and J. J. Brooks, Concrete Technology, Pearson Publications, 2006.
- P. Kumar Mehta, Paulo J. M. Monteiro, Concrete: Microstructure, Properties, and Materials, McGraw Hill Education, 4th Edition, 2017.
- Zongjin Li, Advanced Concrete Technology, John Wiley and Sons, Inc., 2011.

Reference Books:

- Santhakumar A. R., Concrete Technology, Oxford University Press, New Delhi, 2007.
- H. F. W. Taylor, Cement Chemistry, Thomas Telford, 2nd Edition, 1997.
- V. S. Ramachandran, Concrete Admixtures Handbook, Noyes Publications, 2nd Edition, 2002.
- Peter Hewlett and Martin Liska, Lea's Chemistry of Cement and Concrete, Elsevier Science and Technology Books, 2019.

SKILLS:

- ✓ After successful completion of this course, students will have the ability to:
- ✓ Perform cement hydration analysis and identify hydration products.
- ✓ Analyze concrete microstructure and assess strength–durability relationships.
- ✓ Conduct and interpret results from NDT methods (UPV, rebound hammer, etc.).
- ✓ Design concrete mixes incorporating admixtures and supplementary materials.
- ✓ Prepare, test, and evaluate special concretes (HPC, SCC, FRC, ferrocement).

Image source:

https://www.google.com/imgres?q=suggest%20an%20image%20for%20advanced%20concrete%20technology&imgurl=https%3A%2F%2Fwww.crown.co.za%2Fimages%2FLatest_news_2022%2FConstruction_World%2FEarly_preparation_to_qualify_for_Advanced_Concrete_Technology_training_urged.jpg&imgrefurl=https%3A%2F%2Fwww.crown.co.za%2Fconstruction-world%2Fproducts-and-services%2F21497-early-preparation-to-qualify-for-advanced-concrete-technology-training-urged&docid=xgnuLfqC1JsHPM&tbnid=AUizhvL3TuEP2M&vet=12ahUKEwiB1eKOq9-PAxV5xDgGHXCxAHYQM3oECGEQAA..i&w=600&h=400&hcb=2&ved=2ahUKEwiB1eKOq9-PAxV5xDgGHXCxAHYQM3oECGEQAA

Image file name: Advanced Concrete Technology

22SEB804 -BRIDGE ENGINEERING

Hours Per Week :

L	T	P	C
3	2	0	4

PREREQUISITE KNOWLEDGE:
Design of Reinforced Concrete Structures & Design of Steel Structures.

COURSE DESCRIPTION & OBJECTIVES:
The objective of this course is to understand the various types of bridges, codal provisions for loading and design standards of bridges, design the superstructure of bridge using different methods and loading conditions and to understand the design of bearings.

MODULE-1

18L+12T+0P = 30 hours

UNIT-1:

INTRODUCTION TO BRIDGE ENGINEERING

Introduction - Classification – Investigation for bridges - Economic span length- Loading standards – IRC and Railway loads – Impact.

UNIT-2: BRIDGE SUB & SUPER STRUCTURE

Evaluation of sub structures – Pier and abutments caps – Design of pier– Abutments – Type of foundations. Super Structure: Slab bridge- Wheel load on slab- effective width method- slabs supported on two edges- cantilever slabs- dispersion length- box culvert

PRACTICES:

- IRC loadings & standards.
- Design of pier.
- Types of foundation for bridges.
- Design of super structure.
- Case study on design of bridge.

MODULE-2

27L+18T+0P = 45 hours

UNIT-1:

DESIGN OF T-BEAM BRIDGE

Design of T beam bridge- Pigeaud‘s method- design of longitudinal girders- Guyon-Messonet method- Hendry Jaegar method- Courbon‘s theory. (Ref: IRC-21).

UNIT-2:

BEARINGS AND EXPANSION JOINTS

Importance of Bearings – Bearings for slab bridges – Bearings for girder bridges – Electrometric bearing – Joints – Expansion joints. Understand the complexities in design of bridges.

PRACTICES:

- Pigeaud's Method for design of T-Beam bridge.
- Design of longitudinal girders.
- Study on IRC 21.
- Bearings for bridges.
- Case study on complexities in bridge design

COURSE OUTCOMES:

Upon successful completion of this course, students will be able to:

CO No.	Course Outcomes	Bloom's Level	Mapping with POs
1	Apply the codal provisions and concept in the design of bridges.	Apply	1,2,4,5,9,10
2	Identify the suitability of bearings for bridges.	Apply	1,2,4,5,9,10
3	Analysis of sub and superstructure of bridge.	Analyse	1,2,4,5,9,10
4	Design of T-Beam bridge and Prestressed Con- crete members.	Evaluate	2,3,4,5,9,10

TEXTBOOK:

- Jagadeesh T. R., Jayaram M. A, Design of bridge structures, PHI learning, 3rd edition, 2021.
- S. Ponnuswamy, Bridge Engineering‖, Tata Mc Graw - Hill Publishing Company Limited, New Delhi, 3rd edition, 2017

REFERENCE BOOKS:

- Structural design manual‖, Precast concrete connection details, Society for the studies in the use of precast concrete, Netherland Betor Verlag, 2009.
- Gerostiza C.Z., Hendrikson C. and Rehat D.R., Knowledge based process planning for construction and manufacturing‖, Academic Press Inc., 1994.
- Indian Road Congress IRC: 21 – 2000.

SKILLS:

- ✓ Identify the type of bridge suitable for different soil and environmental conditions.
- ✓ Design the bridge under primary and secondary loading conditions.
- ✓ Determination of suitability of bridge to the site condition.

https://media.istockphoto.com/id/532021273/photo/construction-in-progress-of-a-mass-rapid-transit-line.jpg?s=612x612&w=0&k=20&c=8kxfQnLdTiprqxGVzYGlBxEK5cQhRdfs2WqYiB5gbLU=

22SEB805 – ADVANCED FOUNDATION ENGINEERING

Hours per week:

L	T	P	C
3	2	0	4

PREREQUISITE KNOWLEDGE:
Soil Mechanics, Basic Mathematics Engineering Geology

COURSE DESCRIPTION AND OBJECTIVES:
Advanced Foundation Engineering is a postgraduate course that provides in-depth knowledge of soil behavior, modern foundation systems, ground improvement techniques, soil–structure interaction, and seismic foundation design. It enables students to analyze complex geotechnical problems, design shallow and deep foundations using IS codes and advanced software like PLAXIS, GEO5, and MATLAB, and understand dynamic behavior of machine foundations. The course emphasizes sustainable foundation practices, digital tools such as BIM and IoT-based monitoring, and explores case studies of iconic structures and failures. Students will develop skills in laboratory investigations, numerical modeling, research, technical reporting, and will be prepared for careers in academia, consultancy, and geotechnical industry.

MODULE-1

12L+0T+12P=24 Hours

UNIT 1:

ADVANCED SOIL BEHAVIOUR & CRITICAL STATE FOR FOUNDATIONS
Critical State Soil Mechanics (CSSM) and stress–strain behavior under foundations.; Anisotropy, strain-softening, stress history, and structure effects in foundation soils.

Advanced shear strength: stress-path methods, cyclic loading, liquefaction potential.; Reliability and variability in soil parameters – Bayesian & probabilistic approaches.

UNIT 2:

SMART GEOTECHNICAL SITE INVESTIGATION & DIGITAL GROUND MODELLING
Integrated site characterization: borehole planning, sampling, GIS-based subsurface mapping.
Modern in-situ tests: CPTu & SCPTu, Pressuremeter Test (PMT), Dilatometer (DMT), MASW & geoelectrical methods.; Development of 3D digital ground models.; Data-driven interpretation using AI/ML for soil property prediction.

PRACTICES:

- This practical involves conducting Consolidated Undrained (CU) Triaxial Test with pore water pressure measurement to determine shear strength parameters under controlled drainage conditions. The soil sample is collected from the VFSTR campus near the Civil Engineering Department excavation site.
- This practical involves performing K_0 (at-rest) Consolidation Test to determine in-situ lateral earth pressure and compressibility characteristics of clay soil. The undisturbed sample is obtained from a construction site near VFSTR University main entrance.

- This practical involves conducting a Cyclic Triaxial Test to study the behavior of soil under repeated loading and to evaluate liquefaction potential. The soil sample is sourced from the low-lying area behind the VFSTR Mechanical Engineering Block.
- his practical involves determining critical state parameters (λ and κ) of soil by using results obtained from triaxial compression testing and plotting p′–q and v–ln(p′) relationships. Soil is collected from the VFSTR campus open ground near the cricket field.
- This practical involves carrying out the Standard Penetration Test in the borehole to determine N-values and evaluate soil resistance. The test location is the VFSTR campus borewell site adjacent to the Civil Engineering Department.
- This practical involves interpretation of Cone Penetration Test data using software to derive soil stratification and bearing capacity. CPT records are collected from the VFSTR proposed academic building foundation site.
- His practical involves creating a 2D/3D digital subsurface ground model using borehole log data and GIS tools. The borehole data used is from the VFSTR campus water tank foundation site.

MODULE-2

18L+0T+18P=36 Hours

UNIT 3:
ADVANCED SHALLOW FOUNDATION DESIGN AND PERFORMANCE MONITORING

Limit State Design for footings, rafts & mats.; Bearing capacity in layered/anisotropic soils, inclined & eccentric loads.; Elastic and consolidation settlements, foundation performance under cyclic & seismic loading.

Instrumentation: settlement plates, tiltmeters, strain gauges, IoT-based monitoring.

UNIT 4:
DEEP FOUNDATIONS – PILES, DRILLED SHAFTS & SMART MONITORING

Load-transfer analysis (t–z and q–z curves), pile–soil–structure interaction.; Axial, lateral, uplift behaviour, group action & negative skin friction.; Pile design using CPT-based methods, API/IS/EC codes, seismic/ liquefaction considerations.

Load testing: static, dynamic (PDA), integrity tests, wireless pile monitoring sensors.

UNIT 5:
GROUND IMPROVEMENT, SUSTAINABLE FOUNDATIONS & EMERGING TECHNOLOGIES

Ground improvement for foundations: PVDs, vibro-compaction, stone columns, deep soil mixing, jet grouting.; Use of geosynthetics, geocells, helical piles, micropiles, diaphragm & secant pile walls.; Bio-mediated soil improvement (MICP-Microbially Induced Calcite Precipitation).

Foundation sustainability: carbon footprint, recycled materials, life-cycle cost analysis.

Smart foundations: sensors, AI-based health monitoring, digital twins in geotechnics.

PRACTICES:

- This practical involves conducting a Plate Load Test to determine the bearing capacity and settlement characteristics of soil for shallow foundations. The test is performed at the VFSTR open ground near the Indoor Stadium.
- This practical involves predicting settlement of a square footing using Schmertmann's method and IS:8009 guidelines. The soil data is taken from a borehole drilled near the VFSTR Civil Engineering Block.
- This practical involves analyzing stress distribution below a shallow foundation using Boussinesq's and Westergaard's theories. The foundation details are based on a hypothetical footing designed for VFSTR lab building.
- This practical involves conducting a Static Axial Pile Load Test to determine load–settlement behavior and ultimate capacity of a driven pile. The test location is at the VFSTR new guest house construction site.
- This practical involves analyzing PDA (Pile Driving Analyzer) test data to evaluate dynamic bearing capacity using wave equation theory. Data is taken from pile installation near VFSTR girls' hostel extension.
- This practical involves preparing a model of a stone column in soft clay and studying load improvement and settlement reduction. Clay is collected from VFSTR low-lying agricultural field.
- This practical involves demonstrating ground improvement using Prefabricated Vertical Drains (PVD) with surcharge loading under controlled laboratory conditions at VFSTR Soil Mechanics Lab.
- This practical involves constructing a geogrid-reinforced soil foundation model and evaluating bearing capacity improvement. Materials used are from the VFSTR Geotechnical Engineering Laboratory.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Mapping with POs	Mapping with PSOs
1	Apply advanced soil mechanics principles to evaluate stress distribution, settlement, and consolidation in different soil types.	Apply	1, 2	1
2	Conduct site investigation and interpret field and laboratory soil test data for foundation design.	Apply	1, 2, 3	1
3	Design shallow and deep foundation systems considering bearing capacity, settlement, and soil–structure interaction.	Analyze	1, 2, 3, 4	1, 2
4	Apply numerical and analytical methods, including software tools (PLAXIS, GEO5, MATLAB), for foundation analysis.	Apply	1, 2, 4	1, 2
5	Evaluate ground improvement techniques and sustainable foundation solutions for challenging soil conditions.	Evaluate	1, 2, 3, 4	1, 2

MAPPING OF SUSTAINABLE DEVELOPMENT GOALS AND INDIAN KNOWLEDGE SYSTEM:



Textbooks:

- Ou C.–Y. (Chang-Yu Ou et al.), Fundamentals of Foundation Engineering, Routledge, 1st Edition, 2024.
- Braja M. Das & Nagaratnam Sivakugan – Principles of Foundation Engineering, 10th Ed. (2024)
- V.N.S. Murthy, Advanced Foundation Engineering, CBS Publishers & Distributors, International Edition, 2022.
- ; Rohit Manglik, Foundation Engineering Advance, EduGorilla Publication, 2024.
- Pile Foundations – IS 2911 (Part 1–4): 2023 & Eurocode 7: 2024 updates

Reference Books

- Braja M. Das, Advanced Soil Mechanics, CRC Press, 5th Edition, 2022.
- V.N.S. Murthy, Geotechnical Engineering: Principles and Practices of Soil Mechanics and Foundation Engineering, CRC Press, 3rd Edition, 2022.
- Gopal Ranjan & A.S.R. Rao, Basic and Applied Soil Mechanics, New Age International, 4th Edition, 2022.
- Michael Tomlinson & John Woodward, Pile Design and Construction Practice, CRC Press, 6th Edition, 2014.

SKILLS:

- ✓ Ability to evaluate and interpret soil behavior, stress distribution, and settlement in different soil types for foundation design.
- ✓ Proficiency in conducting field investigations and laboratory soil testing, and interpreting geotechnical data for design purposes.
- ✓ Capability to design shallow and deep foundation systems, considering bearing capacity, settlement, and soil–structure interaction.
- ✓ Skill in applying numerical and analytical methods, including software tools like PLAXIS, GEO5, and MATLAB, for foundation analysis.
- ✓ Competence in evaluating and implementing ground improvement and sustainable foundation techniques for challenging soil conditions.

Image source: https://www.technostructacademy.com/blog/wp-content/uploads/2024/05/1692330994246.webp

Image file name: Advanced Foundation Engineering

22SEB806-ADVANCED STEEL STRUCTURAL DESIGN

Hours Per Week :

L	T	P	C
3	0	2	4

PREREQUISITE KNOWLEDGE: Structural Analysis, Basic Steel Design (IS 800:2007)
.

COURSE DESCRIPTION & OBJECTIVES:

This course focuses on the design and detailing of complex steel structures beyond conventional building frames. Students will learn to design industrial steel structures, trusses, plate girders, gantry girders, towers, chimneys, cold-formed sections, and composite structures using the latest IS codes and limit state method. It includes wind and seismic analysis, fatigue considerations, and software-based modeling and detailing

MODULE-1

18L+0T+12P= 30 hours

UNIT-1:

DESIGN PHILOSOPHY & CODE PROVISIONS

Review of IS 800:2007 – Limit State Method, Limit State vs Working Stress Method in advanced applications, Fatigue, buckling, and stability in steel design, Fire resistance and corrosion protection

UNIT-2:

LOADS, STRUCTURAL BEHAVIOUR & TALL STRUCTURES

Load types and combinations: dead, live, wind, seismic (IS 875, IS 1893), Dynamic loading and fatigue effects, Design of self-supporting lattice towers and guyed masts (IS 802), Transmission tower member design, Steel chimneys – wind and thermal stress design (IS 6533)

PRACTICES:

- STAAD.Pro model of an industrial steel building under wind load
- Tekla/AutoCAD connection detailing.
- Portal frames with rigid connections detailing

MODULE-2

27L+0T+18P= 72 hours

UNIT-1:

PLATE GIRDERS & BOX GIRDERS

Design of welded plate girders with and without stiffeners, Shear buckling, web stiffeners, flange design, Box girders for highway and railway bridges (IS 800, IRS codes), Serviceability and fatigue considerations in girders

UNIT-2:

TRUSSES, PORTAL FRAMES & RIGID CONNECTIONS

Design of roof trusses and lattice girders for various spans, Design of purlins (IS 801) and bracing systems, Portal frame design with rigid joints, Connection detailing for bolted and welded joints.

UNIT-3:

Cold-Formed & Composite Construction
Cold-formed steel sections (IS 801, IS 811) – local buckling, effective section properties, Composite beams, columns, and floors (IS 11384), Fire resistance and durability in composite structures, Detailing considerations for composite connections

PRACTICES:

- STAAD.Pro design of a welded plate girder bridge span
- ETABS model of a composite floor system
- AutoCAD/Tekla detailing of gusset plates, composite beams, and connections

COURSE OUTCOMES:
Upon successful completion of this course, students will be able to:

CO No.	Course Outcomes	Bloom's Level	Mapping with POs
1	Apply IS codes and limit state design principles to advanced steel structures.	Apply	1,2,3,5
2	Analyze wind, seismic, fatigue, and dynamic load combinations for tall and long-span steel structures.	Analyse	1,2,3,4.5
3	Design and detail plate girders, box girders, trusses, towers, chimneys, and portal frames.	Apply	1,2,3,5,12
4	Design cold-formed and composite steel-concrete structural elements.	Apply	1,2,3,4,5,11
5	Use structural software for advanced steel design and detailing.	Apply	1,2,3,5,12

TEXT BOOK:

- N. Subramanian – Design of Steel Structures, Oxford University Press.
- Duggal S.K. – Limit State Design of Steel Structures, McGraw Hill.
- Dayaratnam P. – Design of Steel Structures, Wheeler Publishers.

REFERENCE BOOKS:

- IS 800:2007 – General Construction in Steel – Code of Practice
- IS 875 (Parts 1–5) – Design Loads for Buildings and Structures
- IS 801, IS 811 – Cold-formed Steel Design
- IS 802 – Transmission Towers Design

- IS 6533 – Design of Steel Chimneys
- IS 11384 – Composite Construction in Structural Steel and Concrete
- SP-6 – Handbook for Structural Engineers (Steel)

SKILLS:

- ✓ Interpret and apply IS 800, IS 875, IS 1893, IS 802, IS 6533, IS 801, IS 811, IS 11384 for advanced steel design.
- ✓ Analyze wind, seismic, fatigue, and dynamic load effects on tall and long-span steel structures.
- ✓ Design and detail plate girders, box girders, trusses, towers, chimneys, and portal frames.
- ✓ Design cold-formed and composite steel-concrete members considering buckling and serviceability.Interpret and apply IS 456, IS 875, IS 1893, IS 2974, IS 3370, IS 4995 for industrial RCC design.

22SEB807 – REPAIR & REHABILITATION OF STRUCTURES

Hours per week:

L	T	P	C
3	2	0	4

PREREQUISITE KNOWLEDGE:

Concrete Technology, IS 456, Awareness of construction techniques and common structural components & Fundamentals of structural analysis and load paths.

COURSE DESCRIPTION AND OBJECTIVES:

This course focuses on the causes, assessment, and repair of distress in concrete structures. It covers the evaluation of deterioration mechanisms, condition survey methodologies, non-destructive and chemical testing techniques, selection of repair materials, and various rehabilitation strategies. The primary objective of this course is to impart knowledge on the causes and mechanisms of deterioration in concrete structures and to develop the ability to identify distress symptoms and evaluate structural conditions. Students will learn various diagnostic techniques, both destructive and non-destructive, to assess the extent of damage and determine appropriate repair and rehabilitation strategies.

MODULE-1

18L+12T+0P=30Hours

UNIT-1:

INTRODUCTION TO REPAIR AND REHABILITATION

Introduction to repair practices, distress identification, and repair management in reinforced concrete structures; causes of distress including structural overloading, poor construction practices, material degradation, permeability of concrete, exposure to aggressive agents, and durability concerns; models for deterioration of concrete; role of environmental factors in structural degradation.

UNIT-2:

CONDITION SURVEY AND DAMAGE ASSESSMENT

Objectives and stages of inspection; preliminary inspection, planning, detailed visual inspection, and field/laboratory testing; documentation of deterioration patterns; estimation of damage and evaluation of structural soundness; formulation of repair strategies based on inspection outcomes.

PRACTICES:

- Case study on a deteriorated concrete structure — distress mapping and photographic documentation.
- Preparation of a repair strategy plan for a given structural problem.
- Durability analysis using permeability test data.
- Visit to an ongoing repair site and report preparation.
- Preparation of distress cause–effect matrix for common concrete failures.

MODULE-2

27L+18T+0P=45 Hours

UNIT-1:

NON-DESTRUCTIVE AND CHEMICAL TESTING METHODS

Non-destructive evaluation methods including rebound hammer, ultrasonic pulse velocity, penetration resistance, pull-out testing, and core sampling; chemical testing procedures such as carbonation depth, chloride content, corrosion potential, cover meter survey, half-cell potentiometer, and resistivity measurement; case studies of RCC buildings with distress for damage identification and assessment.

UNIT-2:

SELECTION OF REPAIR MATERIALS AND METHODS

Criteria for selection of repair materials including strength, compatibility, durability, and application ease; materials such as premixed cement concrete, polymer-modified mortars, epoxy systems, polyester resins, and protective coatings; repair methods including guniting, shotcreting, polymer concrete, reinforcement replacement, impregnation, overlays, slurry injection, plate bonding, ferrocement jacketing, RCC jacketing, fiber wrapping, and electrochemical treatments.

UNIT-3:

REPAIR AND REHABILITATION STRATEGIES

Strategies for structural repair and rehabilitation; stress reduction techniques; strengthening and repair of columns, beams, and slabs; propping and temporary supports; foundation rehabilitation methods; preventive and corrective measures to extend service life; guidelines and codes of practice for sustainable repair solutions.

PRACTICES:

- Rebound hammer & UPV testing on an in-service structure — result interpretation.
- Carbonation depth measurement and chloride content determination.
- Demonstration/practice of guniting or shotcreting.
- Design and detailing of a fibre wrap retrofitting scheme for a column.
- Preparation of a rehabilitation proposal with cost estimation and method statement.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Mapping with POs	Mapping with PSOs
1.	Identify causes and mechanisms of deterioration in concrete structures.	Understanding	1, 2, 4, 6 & 7	1, 2
2.	Plan and execute condition surveys for distress assessment.	Applying	1, 2, 3, 4, 6 & 7	1, 2
3.	Select and conduct suitable NDT and chemical tests for evaluating structural integrity.	Applying	1, 2, 3, 4, 6 & 7	1, 2
4.	Recommend suitable repair materials and methods for different structural problems.	Analyzing	1, 2, 3, 4, 6 & 7	1, 2

5.	Design and plan rehabilitation strategies for various structural components and foundations.	Creating	1, 2, 3, 4, 6 & 7	1, 2

MAPPING OF SUSTAINABLE DEVELOPMENT GOALS AND INDIAN KNOWLEDGE SYSTEM:



TEXT BOOKS:

- Concrete Structures: Repair, Rehabilitation and Retrofitting – Denison Campbell, Allen and Harold, CRC Press, 2022.

REFERENCEBOOKS:

- Concrete Repair to EN 1504 – Michael Raupach, Carmen Andrade, CRC Press, 2021.
- Handbook of Repair and Rehabilitation of RCC Structures – P. Bhattacharjee, McGraw Hill, 2023.
- Repair, Protection and Waterproofing of Concrete Structures – Philip A. Scallan, Elsevier, 2022.

SKILLS:

- ✓ Structural distress diagnosis.
- ✓ Non-destructive evaluation techniques.
- ✓ Repair material selection and method application.
- ✓ Rehabilitation strategy design and documentation.

Image source: https://constrofacilitator.com/repair-and-rehabilitation-of-structure/

Image file name: Repair & Rehabilitation of Structures

M.Tech. CSE

R22 C22 - COURSE STRUCTURE

Pre - Semester

Course Code	Title of the course	L	T	P	C	Course type
22SAB101	Orientation Session	0	2	0	1	Binary graded
22AMB101	IT workshop and cybersecurity	0	0	2	1	Binary graded
	Total	**4**			**2**	

I Year I Semester

Course Code	Title of the course	L	T	P	C	Course type
22CSB101	Data Structures and Algorithms	2	2	2	4	Professional Core
22CSB102	Machine Learning	2	2	2	4	Professional Core
22CSB103	Internet of Things	2	2	2	4	Professional Core
	Department Elective	3	2	0	4	Elective
22CSB104	**Teaching Assistantship**	0	0	2	1	Binary graded
22ENB101	**Indian Knowledge System**	0	2	0	1	Binary graded
22CSB109	**Work-in-lieu of a course***				2	Elective & Floating Credit
	Sub Total				**20**	
	Add on course -1				3	
	Total				**23**	

I Year II Semester

Course Code	Title of the course	L	T	P	C	Course type
22CSB105	Cloud Computing	2	2	2	4	Professional Core
22CSB106	Big Data and Analytics	2	2	2	4	Professional Core
	Department Elective	3	0	2	4	Elective
	Department Elective	3	0	2	4	Elective
22MSB101	Research Methodology & IPR	1	2	0	2	Interdisciplinary
22CSB107	Interdepartmental Project	0	0	2	1	Project
22CSB108	Teaching Assistantship	0	0	2	1	Binary graded
	Sub Total	**11**	**06**	**12**	**20**	
	Add on course -2				3	
	Total				**23**	

II Year I Semester

Course Code	Title of the course	L	T	P	C	Course type
22CSB201 / 22CSB202	Internship / Project	0	2	24	13	Project
	Sub Total	**0**	**2**	**24**	**13**	
	Add on course -3 (MOOCs Course)				3	
	Total				**16**	

II Year II Semester

Course Code	Title of the course	L	T	P	C	Course type
22CSB203 / 22CSB204	Internship / Project	0	2	24	13	Project
	Sub Total	**0**	**2**	**24**	**13**	
	Add on course -4 (MOOCs Course)				3	
	Total				**16**	

DEPARTMENT ELECTIVES–STREAM-WISE

Artificial Intelligence and Machine Learning

Course Code	Course Title	L	T	P	C
22CSB801	Artificial Intelligence	3	0	2	4
22CSB802	Artificial Neural Networks	3	2	0	4
22CSB803	Deep Learning	3	0	2	4
22CSB804	Computer Vision	3	0	2	4
22CSB805	Pattern Recognition	3	2	0	4
22CSB806	Digital Image Processing	3	0	2	4

Data Science

Course Code	Course Title	L	T	P	C
22CSB807	Data Handling and Visualization	3	0	2	4
22CSB808	Statistical Foundations of Data Science	3	0	2	4
22CSB809	Natural Language Processing	3	2	0	4
22CSB803	Deep Learning	3	0	2	4
22CSB810	Time Series Analysis and Forecasting	3	0	2	4
22CSB811	Kernel Methods for Pattern Analysis	3	0	2	4

Cyber Security

Course Code	Course Title	L	T	P	C
22CSB812	Wireless Sensor Networks	3	0	2	4
22CSB813	Mobile Ad-hoc Networks	3	0	2	4
22CSB814	Blockchain Technologies	3	0	2	4
22CSB815	Mobile and Wireless Security	3	0	2	4
22CSB816	Advanced Cryptography	3	0	2	4
22CSB817	Digital Forensics	3	0	2	4

B.TECH. PROGRAM.

MAJOR REVISION - R22 & C22

COURSE STRUCTURE – C22

Induction program

Course Code	Course Title	L	T	P	SL	C	Course category
22SA101	Orientation program (Induction Program)	0	2	0	0	1	Binary graded
Total		**0**	**2**	**0**	**0**	**1**	

Pre - semester

Course Code	Course Title	L	T	P	SL	C	Course category
22MT101	Foundations of Engineering Mathematics	0	3	2	0	1	Basic Sciences
22MT102	Engineering Mathematics Fundamentals						
22EN101	English Language and Communication	0	3	2	0	1	Humanities
22TP101	Foundation to Quantitative Aptitude and Logical Reasoning	0	5	0	0	1	Humanities
22AM101	IT Tools	0	0	2	0	1	Basic Engineering
22SS104	Stories of Indian Independence	0	2	0	0	1	Binary graded
22EN102	Universal Human Values	0	2	0	0	1	Binary graded
Sub-Total		**0**	**15**	**06**	**0**	**06**	
Total		**21**			**0**	**06**	

I Year I Semester (MPC Stream)

Course Code	Course Title	L	T	P	SL	C	Course category
22MT103	Linear Algebra	3	2	0	3	4	Basic Sciences
22MT105	Calculus and Ordinary Differential Equations						
22PY101	Engineering Physics	3	0	2	3	4	Basic Sciences
22CT102	Engineering Chemistry						
22EE101	Basic of Electrical & Electronics Engineering	2	0	2	2	3	Basic Engineering
22ME101	Engineering Drawing						
22CS101	Programming in C	2	0	4	2	4	Basic Engineering
22EN103	English Proficiency and Communication Skills (PET)	0	0	2	0	1	Humanities
22CT101	Environmental Studies	2	2	0	2	3	Basic Sciences
22MS101	Management Studies						Humanities
						1	Binary graded
						1	Binary graded
						1	Binary graded
Total						**22**	

I Year II Semester (MPC Stream)

Course Code	Course Title	L	T	P	SL	C	Course category
22MT103	Linear Algebra	3	2	0	3	4	Basic Sciences
22MT105	Calculus and Ordinary Differential Equations						
22PY101	Engineering Physics	3	0	2	3	4	Basic Sciences
22CT102	Engineering Chemistry						
22EE101	Basic of Electrical & Electronics Engineering	2	0	2	2	3	Basic Engineering
22ME101	Engineering Drawing						
22CS102	Problem Solving through Python	2	0	2	2	3	Basic Engineering
22EN104	Technical English Communication	1	0	2	1	2	Humanities
22CT101	Environmental Studies	2	2	0	2	3	Basic Sciences
22MS101	Management Studies						Humanities
22CY101	Cyber security	0	1	1	0	1	Basic Engineering
						1	Binary graded
						1	Binary graded
						1	Binary graded
						1	Binary graded
Total						**22**	

II Year I Semester

Course Title	L	T	P	SL	C	Course category
Maths (P&S)	3	2	0	3	4	Basic Sciences
Dept. Specific – Physics / Domain Subject Semiconductor Physics	2	0	2	2	3	Basic Sciences
Data Structures	2	2	2	2	4	Basic Engineering
Design Thinking and Engineering Orientation		2			1	Basic Engineering
Signals and Systems	2	2	2	2	4	Professional Core-1
Digital Electronics	2	2	2	2	4	Professional Core-2
Network Theory	3	2	0	3	4	Professional Core-3
Total	**14**	**12**	**8**	**14**	**24**	**34**

II Year II Semester

Course Title	L	T	P	SL	C	Course category
Dept. Specific - Maths (NUMERICAL METHODS)	2	2		2	3	Basic Sciences
Industry – Interface (I^2) Course			2		1	Dept. Elective-1
	3			3	3	Open Elective-1
Electronics Devices and Circuits	3	-	2	3	4	Professional Core-4
Microcontrollers	2	2	2	2	4	Professional Core-5
FPGA based System Design	2	2	2	2	4	Professional Core-6
Communication Systems	2	2	2	2	4	Professional Core-7
					1	Project
Total					**24**	

III Year I Semester

Course Title	L	T	P	SL	C	Course category
Soft Skills Laboratory			2		1	Humanities
Quantitative Aptitude & Logical Reasoning		2			1	Humanities
Digital Signal Processing					3	Dept. Elective-2
Control Systems	2	2	0	2	3	Professional Core-8
Analog IC Design	2	2	2	2	4	Professional Core-9
EMTL	3	0	2	3	4	Professional Core-10
DICD	3	0	2	3	4	Professional Core-11
Sub-Total					**20**	
Honours/Minors (Add-on) VLSI Testing/ Nano Electronic Device Modelling/ Linux based course					**4**	Honours/Minors
Total					**24**	

III Year II Semester

Course Title	L	T	P	SL	C	Course category
Professional Communication Skills					1	Humanities
Verification Using System Verilog					4	Dept. Elective-3
Advanced Digital System Design					4	Dept. Elective-4
					3	Open Elective-2
Scripting language	3	0	2	3	4	Professional Core-12
Microchip Fabrication technology	2	0	2	2	3	Professional Core-13
					1	Project
Sub-Total					**20**	
Honours/Minors (Add-on) Mixed Signal Design/ Thin Films Characterization/ Photovoltaic Devices and Energy Conversion					**4**	Honours/Minors
Total					**24**	

IV Year I Semester

Course Title	L	T	P	SL	C	Course category
Dept. Specific (Professional Ethics)		2	2		2	Humanities
CMOS RFIC Design/System-on-Chip Design /ASIC Design					4	Dept. Elective-5
Photonics and Optical Circuits/Compound Semiconductor Devices/ AI in VLSI Design					4	Dept. Elective-6
Work-in-Lieu of Course			8		4*	Dept. Elective-7
					3	Open Elective-3
Sub-Total					**17**	
Honours/Minors (Add-on) Hardware security/Low Power Digital circuit Design/ MEMS/ NEMS					**4**	Honours/Minors
Total					**21**	

IV Year II Semester

Course Title	L	T	P	SL	C	Course category
Project/Internship					12	Project/Internship
Sub-Total					**12**	
Honours/Minors (Add-on) :-IoT Architectures/ Neuromorphic Computing/ Quantum Computing in VLSI					**4**	Honours/Minors
Total					**16**	

22ECXXX – SEMICONDUCTOR PHYSICS AND DEVICES

Hours per week:

L	T	P	SL	C
2	0	2	2	3

PREREQUISITE KNOWLEDGE: Basics of Physics, Basic concept of Differentiation and Integration.

COURSE DESCRIPTION AND OBJECTIVES:

This course is aimed at offering fundamental concepts of semiconductor Physics and devices . It starts with the concepts of the fundamentals of semiconductors, how it brings revolution into the industry. Then discussion will happen on Junction Diode, Transistor, MOSFET and other basic devices that are designed with semiconductor materials. As a first-level course in electronics, the objective of this course is to form the basis for the understanding of advanced electronic courses that are offered in subsequent semesters.

MODULE-1

12L+0T+06P+12 SL= 30 Hours

UNIT-1: Introduction to Semiconductor Physics:

Electrons in periodic Lattices, E-k diagrams, Energy bands, intrinsic and extrinsic semiconductor, direct and indirect bandgap semiconductors, elemental and compound semiconductor

UNIT-2: Semiconductor Equations

Introduction to semiconductor equations and carrier statistics: Poisson‘s and continuity equations, Fermi-Dirac statistics and Boltzmann approximation to the Fermi Dirac statistics.

PRACTICES:

- To determine the static and dynamic resistances of given P-N Junction diode
- To determine the break down voltage of given Zener diode
- Determination of the ripple factor and efficiency of Half wave Rectifier with and without filter
- Determination of the ripple factor and efficiency of Full wave Rectifier with and without filter
- Study of I/P and O/P response of clippers and clamper circuits for a given sine wave input

MODULE-2

27L+0T+18P+27SL=48 Hours

UNIT-1: Semiconductor Diodes:

Barrier formation in metal semiconductor junctions, PN homo and hetero- junctions; characteristics, I-V characteristics, and small signal switching models; Avalanche breakdown, Zener diode, Schottky diode, Tunnel Diode, IMPATT Diode, Gunn Diode, Narrow base diode.

UNIT-2: BJT:-

Structure, operation, I-V characteristics, Ebers-Moll Model, CE, CB, CC Configurations, large and small signal models.

UNIT-3: Field Effect Devices:

JFET/HEMT, MIS structures and MOSFET operation; MOSFET characteristics and small signal models; Common emitter and common source amplifiers; Emitter and source followers

PRACTICES:

- To determine I/P and O/P Characteristics of BJT in CB Configuration
- To determine I/P and O/P Characteristics of BJT in CE Configuration
- To determine I/P and O/P Characteristics of BJT in CC Configuration
- To determine the amplification factor of given MOSFET through Drain and transfer characteristics

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Understand the semiconductor device physics	Understanding	1,2	1,2,11
2	Understand the principle behind the PN junctions formation	Apply	2	1,2,11
3	Analyze the configurations of BJT/MOSFET	Apply	2	1,2,5,11
4	Create the BJT/MOSFET model for low frequency application	Analyse	2	1,2,3,5,11

Mapping of SDGs and IKS

Sustainable Development Goals (SDGs)	**Indian Knowledge System**
SDG 4 (Quality Education) SDG 9 (Industry, Innovation, and Infrastructure) SDG 11 (Sustainable Cities & Communities) SDG 12 (Responsible Consumption and Production)	**No**

TEXT BOOKS:

1. Solid State Electronic Devices, B. G. Streetman, and S. K. Banerjee, Pearson, 7th edition, 2018.
2. Semiconductor Physics and Devices, D. Neamen, and D. Biswas, McGraw-Hill Education, 4th edition, 2017..

REFERENCEBOOKS:

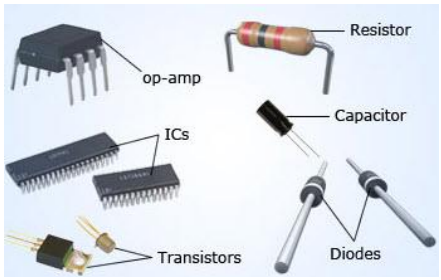
1. Fundamentals of Microelectronics, B. Razavi, Wiley, 3rd Edition, 2021.
2. Physics of Semiconductor Devices, S. M. Sze and K. N. Kwok, John Wiley & Sons, 3rd edition, 2006.
3. Electronic Devices and Circuit Theory, Robert L Boylestad and Louis Nashelsky, Pearson, 11th Edition, 2018.

SKILLS:

- Understand the basic of Semiconductor.
- Able to analyze semiconductor devices.
- Able to design DC sources
- Able to understand Amplifiers

Image source https://www. elprocus.com /wp-content/ uploads/ 2016/06/2016-06-10_11-36-59.jpg

Image file name:


Resistor
op-amp
Capacitor
ICs
Transistors
Diodes

22CS201 - DATA STRUCTURES

Hours Per Week:

L	T	P	SL	C
2	2	2	2	4

PREREQUISITE KNOWLEDGE: Programming in C

COURSE DESCRIPTION & OBJECTIVES:

This course is aimed at offering fundamental concepts of data structures and explains how to implement them. It begins with the basic concepts of data, data structures and then introduces the primitive and non-primitive data structures in detail. It forms the basis for understanding various ways of representing data and its usage in different computing applications.

MODULE-1

12L+12T+12P+12SL= 48 Hours

UNIT-1

DATA STRUCTURES BASICS:

Basic Terminology – data, information, datatype; Data Structures – Introduction, storage structures- sequential and linked storage representations; classification of data structures. Applications of data structures.

Searching: Linear Search and Binary Search.

Sorting: Selection Sort, Bubble Sort, Insertion Sort, Quick Sort and Merge Sort.

UNIT-2

LINKED LISTS, STACKS & QUEUES:

Linked List: Introduction, Types of linked list – Singly linked list, doubly linked list and circular linked list, representation of linked list, Operations of linked list: Traverse forward/ reverse order, searching, insertion and deletion; Applications of linked lists.

Stack – Introduction, array and linked representations, implementation, and their applications; **Queue** – Introduction, array, and linked representations, implementation; Types – Linear, circular and doubly ended queues – operations; Applications of Queues.

PRACTICES:

Problems on Recursion – Level 1

- Find the product of 2 numbers using recursion.
- Find the sum of natural numbers using recursion.
- Find the factorial of a number using recursion.
- Find the Nth term of the Fibonacci series using recursion.
- Calculate the power using recursion.
- Write a recursive program for checking if a given number is a prime number.
- Given two integers write a function to sum the numbers without using any arithmetic operators.
- Convert a decimal to binary using recursion.
- Print all factors using recursion.
- Find the maximum product of digits among numbers less than or equal to N.

Problems Recursion – Level 2

- Implement insertion sort recursively.
- Write a program to find the numbers less than N that are product of exactly 2 distinct prime numbers - using recursion.
- Implement selection sort recursively.
- Find the middle of a singly linked list using recursion.
- Find the sum of even numbers of an array using recursion.

- Check if a given array is in sorted order using recursion.
- Print alternate nodes of a linked list using recursion.
- Reverse a doubly linked list using recursion.
- Write a recursive function that returns all permutations of a given list.
- Implement bubble sort recursively.

Problems on Sorting and Searching – Level 1

- Implement the insertion sort function.
- Implement the bubble sort function.
- Implement the quick sort function.
- Implement the merge sort function.
- Implement the selection sort function.
- Implement linear search function.
- Implement binary search function.

Problems on SLL – Level 1

- Implement the insert function to insert nodes into a singly linked list (ascending order).
- Implement the insert function to insert nodes into a singly linked list (descending order).
- Implement the search node function.
- Implement the delete node function.
- Display forwards function.
- Display backwards function.
- Count the number of nodes in a singly linked list.
- Swap alternate nodes of a singly linked list.
- Move last node to the front of the linked list.
- Move first node to the last of the linked list.

Problems On Stacks – Level 1

- Implement two stacks using a single array.
- Given an array replace every element with nearest greater element on the right.
- Given a stack reverse the elements using only push and pop functions.
- Postfix evaluation using stack.
- Balance symbols.
- Find the middle element in a stack.
- Remove the middle element from a stack.
- Implement push and pop using a linked list.
- Given an array of characters with the middle marked by X, check if the string is a palindrome.
- Maximum sum in sliding window.

Problems On Queues – Level 1

- Write a program to accept two numbers as input check if they are equal.
- Write a program to accept two characters as input and check if they are equal.
- Write a program to accept two numbers as input and print the greater of the 2 numbers.
- Write a program to accept two numbers as input and print the lesser of the 2 numbers.
- Write a program to accept 3 numbers as input and print the maximum of the 3.
- Write a program to accept 3 numbers as input and print the minimum of the 3.
- Write a program to accept a number as input and print EVEN if it is an even number and ODD if it is an odd number.
- Write a program to accept a number as input and check if it is divisible by 3. If it is divisible by 3 print YES else print NO.
- Write a program to accept a number as input and check if it is divisible by both 3 & 5. If it is divisible print YES else print NO.
- Write a program to accept a number as input and check if it is positive, negative or zero.

Problems on DLL – Level 1

- Implement insert function.
- Implement display forward function.
- Implement display backward function.
- Implement a search function.
- Implement delete function.
- Reverse a doubly linked list from M to N.
- Find the sum of the odd and even nodes.
- Count odd keys of the linked list.
- Merge two sorted lists.
- Delete adjacent duplicate nodes.

Problems on CLL – Level 1

- Insert function (circular doubly linked list).
- Search function.
- Display forward.
- Display backward.
- Delete node (circular doubly linked list).
- Print the middle N nodes of a circular singly linked list.
- Move the last node of a circular singly linked list to the beginning.
- Delete adjacent duplicate nodes of a circular singly linked list.
- Delete nodes greater than a value from a circular doubly linked list.
- Find the sum of the nodes of a circular linked list.

Problems on Linked List – Level 2

- Given 2 sorted linked lists, print the common elements.
- Reverse a list (using Stack).
- Given a pointer to a node (not the last node), delete the node.
- Reverse a list (Recursive).
- Reverse a list (Iterative).
- Reverse a singly linked list in pairs (recursive).
- Reverse a singly linked list in pairs (iterative).
- Check if a singly linked list is a palindrome or not.
- Remove the loop if exists.
- Given 2 linked lists with data in the ascending order, merge them into a single list.

MODULE-2

18L+18T+18P+18SL=72 Hours

UNIT-1

TREES:

Trees: Basic Terminology, Binary Tree – Introduction, properties, array, and linked representations; Tree traversals and their implementation;

UNIT-2

Huffman coding using Binary Tree, Heap Sort, BST – definition and operations, AVL trees – definition and construction; Applications of binary trees.

UNIT-3

GRAPHS & HASHING:

Graphs: Basic Terminology, Traversals - Breath First Search(BFS) and Depth First Search(DFS); Applications of graphs. Single Source Shortest Path using ***Dijkstra's Algorithm*** and Bellman-Ford Algorithm.

Hashing: Introduction, Different hash functions, collision: avoidance and handling methods.

PRACTICES:

Problems on BST – Level 1

- Insert function.
- Insert function (recursive).
- Search function.
- Pre order traversal.
- Post order traversal.
- In order traversal.
- Level order traversal.
- Delete child node.
- Delete parent node.
- Delete nodes greater than a value from a circular doubly linked list.
- Implement the Heap sort function.
- Implement Huffman coding using Binary Tree

Problems on Graphs – Level 1

- Implement Graph data structure.
- Implement BFS - iterative solution.
- Implement BFS - recursive solution.
- Implement DFS - iterative solution.
- Implement DFS - recursive solution.
- Check if given graph is strongly connected or not.
- Check if given graph is strongly connected or not - using DFS.
- Given a graph find the arrival and departure time of its vertices in DFS. Arrival time is the time when the vertex was explored for the first time, and departure time is the time at which all the neighbours are explored and are ready to backtrack.
- Given a directed acyclic graph and a source vertex, find the cost of the shortest path from source vertex to all other vertices present in the graph. If a vertex cannot be reached from given source vertex that distance may be printed as infinite.
- Given an undirected graph, check if the graph is 2 edge connected or not.

Problems on Hashing – Level 1

- Print a binary tree in vertical order.
- Find whether an array is subset of another array.
- Given an array A [ ] and a number x, check for pair in A [ ] with sum as x.
- Minimum operation to make all elements equal in array.
- Maximum distance between two occurrences of same element in array.
- Check if a given array contains duplicate elements within k distance from each other.
- Find duplicates in a given array when elements are not limited to a range.
- Most frequent element in an array.
- Smallest subarray with all occurrences of a most frequent element.
- First element occurring k times in an array.

Problems on Graphs – Level 2

- Find the shortest graph distances between every pair vertex in a given path. Assume that the graph does not have any negative edges.
- Find the shortest graph distances between every pair of vertices in a given path. The graph can have negative edges.
- Detect cycle in DFS.
- Count the number of connected components of a graph represented in the adjacent matrix.
- Count the number of connected components of a graph represented in the adjacent matrix - using DFS.

- Find a spanning tree - not necessarily a minimum spanning tree.
- Detect cycle in an undirected graph.
- Given an undirected graph, find its depth.
- Determine if a directed graph has a unique topological ordering.
- Given a directed acyclic graph and two vertices v and w, find the lowest common ancestor.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Mapping with POs
1	Explore the organization of several ADTs and the manipulation (searching, insertion, deletion, traversing) of data stored in various data structures.	Apply	1,2
2	Apply different data structures to solve a given problem.	Apply	1, 3, 4
3	Analyze the efficiency of using different data structures and choose the efficient data structure for solving a given problem.	Analyze	1, 2
4	Assess efficiency trade-offs among different data structure implementations or combinations.	Analyze	1, 2
5	Design programs using a variety of data structures, including hash tables, binary and general tree structures, search trees, heaps, graphs, and AVL trees.	Create	1, 2

MAPPING OF SUSTAINABLE DEVELOPMENT GOALS (SDGs) AND INDIAN KNOWLEDGE SYSTEM (IKS):



TEXTBOOKS:

1. Reema Thareja, "Data Structures Using C", 2nd Edition, Oxford University Press, 2014.
2. Seymour Lipschutz, "Data Structures with C", 1st Edition, McGraw Hill Education, 2017.

REFERENCE BOOKS:

1. Ellis Horowitz and Sartaj Sahni, "Fundamentals of Data Structures", illustrated edition, Computer Science Press, 2006.
2. Richard F. Gilberg and Behrouz A. Forouzan, "Data Structures: A Pseudocode Approach with C", 2nd Edition, CENAGE Learning, 2005.
3. R G Dromey and Pearson, "How to solve it by Computer", 2nd edition, Impression edition, 1998.

SKILLS:

- ✓ Experienced to Store data and various types of data to handle.

- ✓ Ordering and sorting of data.
- ✓ Indexing and Searching of required data from large data sequences.
- ✓ Exposed to various characteristics such as Linear or non-linear, Homogeneous or heterogeneous and Static and Dynamic.

Image:

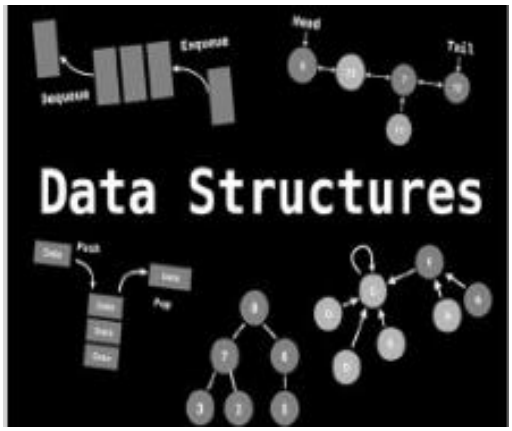


Image Source: https://www.youtube.com/watch?v=Qmt0QwzEmh0

22BT203 - DESIGN THINKING AND ENGINEERING ORIENTATION

Hours Per Week:

L	T	P	SL	C
0	0	2	0	1

PREREQUISITE KNOWLEDGE: Elementary Mathematics, Organic Chemistry
COURSE DESCRIPTION & OBJECTIVES:
In order to provide the student with cutting edge knowledge on the planning, development, and application of design thinking principles in project management. Design thinking in Biotechnology fosters innovative solutions by centering on user needs and real-world problems. This course drives impactful advancements in health care, agriculture and environment.

MODULE - 1

0L+0T+12P+0SL = 12 Hours

UNIT - 1
DESIGN THINKING:
Different stages of the design thinking process, need for design thinking in entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Start-up & Make

in India); Practical applications of design thinking in industry verticals – product, process, research, etc.

UNIT - 2

REACTOR DESIGN AND SMART BIOREACTOR SYSTEMS:

Reactor design concepts and its importance; Case studies for the design of bioreactors; Overview of smart bioreactor design

TRANSACTIONS:

- Design thinking in Bioentrepreneurship.
- Case study for design thinking with an example of a bio-product manufacturing industry.
- Smart Bioreactor Systems.

MODULE - 2

0L+0T+18P+0SL = 18 Hours

UNIT - 1

DESIGN STRATEGY AND PROTOTYPING:

Principles for designing and building a prototype; Use of computer-aided tools for visual depiction; Validation of assumptions and prototypes under simulated user conditions; Redesign and customization to suit requirements; Field survey and cost analysis.

UNIT - 2

DESIGN STRATEGIES IN LIFE SCIENCES:

Ideation techniques for designing nanomaterials and drug discovery for infectious diseases; Building molecular prototypes using computer-aided design tools.

UNIT - 3

CASE STUDIES AND EMERGING TRENDS IN BIO-DESIGN:

Case studies on successful applications of design thinking in life sciences; Emerging trends in bio-design and bioprocessing; Integration of AI and computational tools in bio-design.

TRANSACTIONS:

- Hands-on exercise on building a prototype using computer-aided design (CAD) tools.
- Simulation-based validation of prototype designs under different conditions.
- Case study on redesign and customization of a biomedical device.
- Group discussion on recent breakthroughs in bio-design and bioprocessing.
- Case analysis of AI-integrated bio-design solutions.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO. No.	Course Outcome	Bloom Level	Mapping with POs
1	Understand and Apply the stages of design thinking and its applications in entrepreneurship development	Apply	1, 2, 6, 9, 11
2	Apply design thinking principles to bio-product manufacturing and smart bioreactor systems	Apply	3, 4, 5, 10
3	Analyse the importance of reactor design concepts in biotechnology industries	Analyse	6, 7, 9, 10
4	Develop prototypes using computer-aided design tools and evaluate them under simulated conditions	Create	7, 9, 10

5	Design molecular prototypes for drug discovery and nanomaterials using ideation techniques and CAD tools	Apply	5, 6, 7

MAPPING OF SUSTAINABLE DEVELOPMENT GOALS (SDGs):



TEXT BOOKS:

1. Liedtka J, and Ogilvie T, "Designing for Growth: A Design Thinking Tool Kit for Managers", Columbia University Press, 1st Edition, 2011.
2. Manglik R, "Bioreactors: Analysis and Design", EduGorilla Publication, 1st Edition, July 2024.

REFERENCE BOOKS:

1. Cuinas I, and Fernandez Iglesias M. J, "Design Thinking for Engineering: A Practical Guide", Institution of Engineering and Technology (IET), 1st Edition, 2023.
2. Kumar K, and Kurni M, "Design thinking: a forefront insight", CRC Press, 1st Edition, 2022.

SKILLS

- ✓ Frame the problem based on insights gathered.
- ✓ Generate innovative solutions through brainstorming.
- ✓ Build models to explore and test ideas.
- ✓ Gather feedback to refine and improve solutions.



https://ssir.org/images/jcogs_img/cache/design-thinking-social-innovation-2010-592x333_-_abcdef_-_ec76adfb59d23efa05b4d7ecdd5601e6950c9f26.webp

22ECXXX – SIGNALS AND SYSTEMS

Hours per week:

L	T	P	SL	C
2	2	2	2	4

PREREQUISITE KNOWLEDGE: Basics of Mathematics–Calculus (Limits of Continuity, Differentiation and Integration), Trigonometry and Complex Numbers.

COURSE DESCRIPTION AND OBJECTIVES: This course introduces the fundamentals of continuous times signals and systems useful for communication engineers. The course objectives are: To study the spectral analysis of periodic and aperiodic signals using Fourier series and Fourier Transform. To analyse continuous time Linear Time Invariant (LTI) systems through Laplace Transform and Fourier Transform. To Understand the process of converting continuous time signals to discrete time signals through the concept of Sampling. To use simulation tools for spectral analysis, for understanding the behaviour systems for various kinds of inputs.

MODULE-1

12L+12T+12P+12SL= 48 Hours

UNIT-1: CONTINUOUS TIME SIGNALS

Review Basic Math: Trigonometry, Differentiation, Integration, and Complex Number theory.

Signals: Classification of continuous time signals, Standard signals, Basic operations on signals.

UNIT-2: CONTINUOUS TIME SYSTEMS

Systems: Representation, Classification, RLC Systems and mathematical model, Linear Time Invariant (LTI) system, Causality and stability of a systems, Analysis of LTI system using Convolution integral and properties, Time domain analysis of LTI systems represented by differential equations.

PRACTICES:

- Introduction to MATLAB
- Generation of continuous time signals.
- Basic operations on the signals.
- Convolution between signals
- Time domain Analysis

MODULE-2

18L+18T+18P+18SL= 72 Hours

UNIT-1: FOURIER ANALYSIS

Fourier Series: Representation of signals using orthogonal functions, Representation of continuous time periodic signals, Trigonometric and Exponential representation, Convergence and Properties of the Fourier series, complex Fourier spectrum.

Fourier Transform: Introduction to Fourier transform, Convergence and Properties, Fourier transform for various signals, Frequency response., analysis of LTI systems. Time domain and Frequency domain aspects of ideal and non-ideal filters, conditions for physical realizability. Bandwidth and rise time relation.

UNIT-2: ANALYSIS USING LAPLACE TRANSFORM

Introduction to Laplace transform and region of convergence, Laplace Transform for various signals, Properties of the Laplace transform, Inverse Laplace transform, Analysis of LTI systems, Stability analysis, Analysis of LTI systems represented by differential equation.

UNIT-3: SAMPLING

Sampling Theorem for band limited signals, Nyquist Rate, Nyquist Interval, Graphical and analytical proof for band limited signals through Impulse sampling, Reconstruction of signal from its samples, Effect of under sampling - Aliasing.

PRACTICES:

- Transformation of signals into time and frequency domains.
- Fourier Series spectrum of periodic signals.
- Periodic signal synthesis using Fourier Series.
- Fourier transform spectrum of aperiodic signals.
- Frequency domain analysis of LTI systems.
- Pole-Zero plot and Stability analysis of a system.
- Sampling, Reconstruction and Analysis of signals.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Mapping with POs
1.	Perform various operations on continuous time signals and systems.	Apply	1, 2, 4, 5, 9, 10,
2.	Apply the concepts of convolution for continuous time LTI systems	Apply	1, 2, 5, 9, 10
3.	Analyse the continuous time signals and systems in frequency domain using Fourier series, Fourier transform and Laplace transform.	Analyze	1, 2, 3, 5, 9, 10,11
4.	Analyse Sampling rate for various continuous time signals and its effects.	Analyze	1, 2, 5, 9, 10,11
5.	Use simulation techniques for analysis of different continuous time signals and systems using modern engineering tools.	Evaluate	1, 2, 3, 4, 5, 9, 10, 11

Mapping of SDGs and IKS

Sustainable Development Goals (SDGs)	Indian Knowledge System
SDG 9 (Industry, Innovation, and Infrastructure) SDG 11 (Sustainable Cities & Communities)	No

TEXT BOOKS:

1. B.P. Lathi and Roger Green, "Linear Systems and Signals," Oxford University Press, 3rd edition, 2022.

2. Alan V. Oppenheim, Alan S. Willsky, and S. Hamid Nawab, "Signals and Systems", 2nd edition, Pearson, 2015.

REFERENCEBOOKS:

1. Simon Haykin, Barry Van Veen, “Signals and Systems”, 2nd edition, Wiley, 2007.
2. Hwei P. Hsu, “Schaum’s Outline of Signals and Systems”, McGraw-Hill Education, 4th edition, 2020.
3. Luis F. Chaparro and Aydin Akan, “Signals and Systems using Matlab”, Academic Press, 3rd edition, 2019.
4. Taan S. Elali, “Continuous Signals and Systems with Matlab”, CRC Press, 3rd edition, 2021

SKILLS:

- Design and Test a LTI system.
- Design and test a stable system.
- Choose the various transforms and their applications in the analysis of signals and systems.
- Choose the desired sampling frequency for a given application like a speech, audio video, and communication.
- Apply transformation to real-world problems involving Bio-signals

Image source: ChatGPT Generated Image

Image file name: SIGNALS AND SYSTEMS


FOUIER
TRANSFORM
Fourior Transforitns

22EN301 – SOFT SKILLS LABORATORY

Hours per week:

L	T	P	SL	C
0	0	2	0	1

PREREQUISITE KNOWLEDGE:
Basics of personality traits and qualities of a good human being and motivation for self-improvement.

COURSE DESCRIPTION AND OBJECTIVES:
This course is designed to equip undergraduate engineering students with essential soft skills that are critical for success in both academic and professional settings. The course will provide a comprehensive foundation in key soft skills such as personality development communication, teamwork and leadership, time management, and getting ready to industry to face different kinds of interviews and develop strategies to win the interviews. Through a combination of theoretical learning and practical exercises, students will enhance their ability to interact effectively with peers, professors, and professionals like interview board members in a variety of settings. Emphasis will be placed on real-world applications, helping students build confidence and develop the interpersonal skills necessary for effective collaboration, innovation, and career advancement This course will help the students, to develop interpersonal and intrapersonal skills, analyze and improve their personality traits. In addition to the above, the learners to be aware of the needs of the industry to focus on preparing for job placement/ industry ready.

MODULE-1

0L +0T+12P-0SL=12 Hours

UNIT-1
PERSONALITY DEVELOPMENT-1:
Analyzing self for personality development through Strengths, Weaknesses, Opportunities and Threats or Challenges. ***Atma-Vichara*** (self-inquiry)

Creating self-awareness through Open Arena, Blind spots, Facade and Unknown areas of individual ***(Jagrat, Swapna, Sushupti, Turiya*** *and the importance of* ***Atma-Bodha.)***

The importance of team building skills and various skills required to build a team along with examples ***(Panchatantra and Mahabharata)***

UNIT-2
PERSONALITY DEVELOPMENT-2:
Importance of goal setting, Edwin Locke's theory of goal setting, setting goals, SMART technique for goal setting, dividing goals. ***Purusharthas (Dharma, Artha, Kama, Moksha)***

Need for the stress management, ways to manage stress, stress management skills and techniques, Stress management strategies.
(*Dhyana* meditation and ***Pranayama*** for holistic well-being and emotional balance)

Major themes of time management, benefits of time management, effective time management, POSEC method, Covey's Time management. ***Dinacharya*** **and** ***Ritucharya***

PRACTICES:

- SWOT analysis
- Johari window
- Team building skills
- Goal setting
- Stress management
- Time management

MODULE-2

0L +0T+18P-0SL=18 Hours

UNIT-1

GETTING READY TO INDUSTRY:

Industry needs: dress sense, appearance, creating an image, image management and etiquettes at work place.

Samskaras (refinement), ancient concepts of ***Aachara*** (right conduct), and ***Sadvritta*** (ideal behavior)

Various language functions, expressions and usage: informal, semi-formal and formal.

UNIT-2

JOB RECRUITMENT PROCESS.

Narrating about self, academic achievements, project works, family background (if required)

Purusharthas and ***Svadharma*** (personal duty or career path).

Participating group discussions, various roles in group discussion, taking turns in the discussion, expressing opinions, agreeing, disagreeing, leading using SPELT technique, consolidating the information and arriving to a conclusion.

Shastrartha**,** Sabha traditions of discourse.

Practicing HR questions.

UNIT-3

DOCUMENT PREPARATRION TO THE NEXT LEVEL:

Collecting the data, finding a suitable template, presenting the objectives, education qualification, projects, co and extracurricular activities, achievements, certifications, hobbies and personal information.

Presenting ambitions, aspirations, successes and persuading**.**

PRACTICES:

- Image management
- Essential language functions and expressions
- Self-introduction
- Group discussion
- Facing interviews
- Resume preparation
- Statement of purpose

COURSE OUTCOMES:

On successful completion of the course, the students will be able to:

CO Nos	Course Outcomes	Blooms Level	Mapping with POs
1	introspect on personal traits (for example strengths, weaknesses, known and unknown areas, hidden etc.,) and emerge as a balanced personality with improved self-awareness and self-worth.	Analyze	11
2	learn the importance of the use of formal language in their professional as well as personal areas to represent their personality by demonstrating gender sensitive language at workplace in the cross cultural environment.	Apply	9
3	Be able to prepare a resume and gain the confidence to face an interview.	Create	10
4	Possess the interpersonal skills to conduct himself/herself effectively in everyday professional and social contexts.	Apply	8
5	Be able to bring professionalism into his/her daily activities.	Apply	8

MAPPING OF SUSTAINABLE DEVELOPMENT GOALS (SDGs) AND INDIAN KNOWLEDGE SYSTEM (IKS):





TEXT BOOKS:

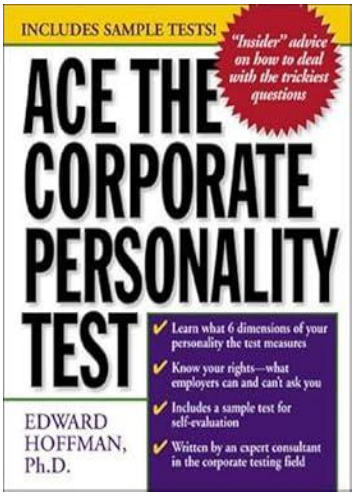
1. Edward Holffman, Ace the corporate personality, McGraw Hill,2001.
2. Adrian Furnham, Personality and intelligence at work, Psychology Press, 2008.

REFERENCE BOOKS:

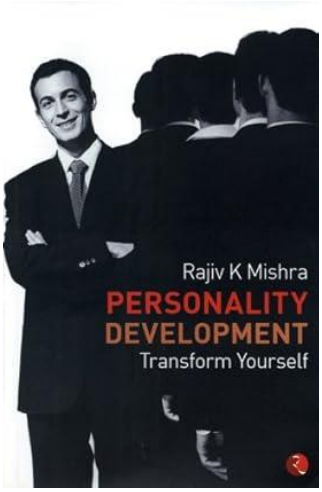
1. John Adair Kegan Page, "Leadership for innovation" 1st edition, Kogan, 2007.
2. Krishna Mohan & NP Singh, "Speaking English effectively" 1st edition, Macmillan, 2008.
3. Dr. S.P. Dhanvel, English and Soft skills, Orient Blackswan, 2011.
4. Rajiv K. Mishra, Personality Development, Rupa& Co. 2004.
    a. https://zety.com/blog/resume-formats for latest resumes

SKILLS:

- ✓ Balancing social and emotional intelligence quotients though analyzing interpersonal and intrapersonal skills.
- ✓ Solving personal and professional life hiccups with confidence and maturity.
- ✓ Career planning with clear personal and professional goals.
- ✓ Preparing tailor made resume and face various job interviews with enriched personality traits.



https://m.media-amazon.com/images/I/51Il3X84bOL._SX342_SY445_.jpg



https://img.bookchor.com/images/cover/596/9788129103451.jpg

22TP301 - QUANTITATIVE APTITUDE & LOGICAL REASONING

Hours Per Week:

L	T	P	SL	C
0	2	0	0	1

PREREQUISITE KNOWLEDGE:
Basic Logical Thinking and Problem-Solving Ability.

COURSE DESCRIPTION AND OBJECTIVES:
The "Quantitative Aptitude & Logical Reasoning" course develops students' problem-solving, analytical, and logical thinking skills through topics like arithmetic, algebra, data interpretation, and puzzles. It prepares learners for aptitude tests and decision-making scenarios, enhancing their speed, accuracy, and confidence to excel in academics, placements, and real-world challenges.

MODULE-1

0L+12T+0P+0SL=12 Hours

UNIT-1
QUANTITATIVE APTITUDE-1:
Number system, LCM & HCF of numbers, Percentage, Ratio and proportion and Partnership.

UNIT-2
QUANTITATIVE APTITUDE- 2:
Profit, loss and discount, Simple Interest & Compound interest, Data Interpretation.

PRACTICES:

- Each concept would be taught in detail in the class.
- Followed by 10 problems solved in the class.
- Timer based questions solving during class room practice.
- Students would have to solve 10 additional problems as homework assignment in each concept.

MODULE-2

0L+18T+0P+0SL=18 Hours

UNIT-1
QUANTITATIVE APTITUDE- 3:
Time and work, Time & distance, Permutation & Combinations, Probability.

UNIT-4
LOGICAL REASONING- 1:
Number series & Letter series, Analogy, Coding & decoding, Syllogisms, Puzzle test.

UNIT-5
LOGICAL REASONING- 2:
Blood relations, Direction sense test, Order & Ranking, Seating Arrangements, Calendar & Clocks.

PRACTICES:

- Each concept would be taught in detail in the class.
- Followed by 10 problems solved in the class.
- Timer based questions solving during class room practice.
- Students would have to solve 10 additional problems as homework assignment in each concept.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Mapping with POs
1	Develop the ability to solve arithmetic and reasoning problems quickly and accurately, without relying on paper-based calculations.	Apply	1, 3, 5
2	Strengthen data interpretation skills for effective analysis and decision-making.	Analyze	1, 4, 5
3	Address the evolving demands of the current job market while preparing individuals for higher studies, including exams such as the CAT, GMAT, etc.	Evaluate	2, 5, 10
4	Enhance analytical skills to evaluate logical statements, arguments, and patterns.	Evaluate	2, 6
5	Develop proficiency in solving reasoning problems like puzzles, analogies, syllogisms, and seating arrangements.	Apply	2, 6, 8

MAPPING OF SUSTAINABLE DEVELOPMENT GOALS (SDGs):



TEXT BOOKS:

1. R. S. Aggarwal- Quantitative Aptitude for Competitive Examinations- S. Chand Publications- Edition-2023.
2. ARIHANT- A New Approach to Verbal & Non-Verbal Reasoning- Arihant Publication- Revised Edition-2021.

REFERENCE BOOKS:

1. Trishna Knowledge Systems- Quantitative Aptitude for Competitive Examinations- Pearson Publication- First Edition- 2013.
2. B.S. Sijwali & S. Sijwali- A New Approach to Reasoning- Arihant Publication- Edition- 2018.
3. R. S. Aggarwal- A Modern Approach to Verbal &Non-Verbal Reasoning-S. Chand Publication- Revised Edition- 2018.

SKILLS:

- Helps enhance problem-solving abilities.
- Improves skills in analyzing and interpreting data from graphs, charts, and tables.
- Encourages the development of critical thinking skills.
- Promotes systematic approaches to problem-solving and making sound decisions.
- Manage time efficiently while solving multiple questions in exams.

Image Source: Quantitative Aptitude & Logical Reasoning

Image file name: Quantitative Aptitude & Logical Reasoning

22ECXXX – Digital Electronics

Hours per week:

L	T	P	SL	C
2	2	2	2	4

PREREQUISITE KNOWLEDGE: Number systems.

COURSE DESCRIPTION AND OBJECTIVES:

This course covers number systems, logic gates, Boolean algebra, and simplifications using SOP & POS forms. It explores K-map minimization, prime implicants, and combinational circuit design, including adders, multiplexers, and decoders. Sequential circuits, flip-flops, shift registers, and counters like mod-n and ring counters are introduced. Finally, it covers finite state machines, state diagrams, and applications like sequence detectors and traffic light control.

MODULE-1

12L+12T+12P+18SL=54 Hours

UNIT-1: BASICS OF LOGIC FUNCTIONS AND SWITCHING ALGEBRA

Review of Number systems, integer and floating point numbers, Compliments, Binary Codes, Logic gates.

Switching Algebra: Boolean algebra, Canonical and Standard Forms – SOP & POS forms, algebraic simplifications and realization using basic and Universal gates.

UNIT-2: MINIMIZATION OF SWITCHING FUNCTIONS AND LOGIC DESIGN

Minimization of Switching Functions : Simplification of switching functions with Karnaugh Map of 3,4 5 variables for both min and max terms, Don't care conditions, Limitations of K-map, AOI and OAI implementations, prime implicants, Essential prime implicants.

logic design: Design with gates-procedure and examples, Adders - Half adder, Full Adder, Parallel binary adder, Subtractor - Half Subtractor, Full subtractor, Parallel Adder/Subtractor

PRACTICES:

- Logic gates
- 1- bit Adders and Subtractors
- Parallel binary adder
- Carry Look ahead adder
- Parallel Adder/Subtractor
- Design of any practical case study

MODULE-2

18L+18T+18P+27SL=81 Hours

UNIT-1: COMBINATIONAL LOGIC DESIGN

Multiplexer, Logic implementation using Multiplexer, Demultiplexer, Decoder, Logic implementation using Decoder, Encoder, limitations of encoder, Priority encoder, Code converters, Magnitude Comparator, Applications like parity generator/checker, Seven Segment LED Display etc.

UNIT-2: SEQUENTIAL LOGIC DESIGN -I

Basics: Classification of sequential circuits

Latches and Flip Flops: Latches and flipflops – SR,D,JK,T, Triggering types and circuits, Master-slave flip-flop, Flip flop conversions.
Registers- Shift registers - SISO, SIPO, PISO, PIPO, Bidirectional shift register, Universal shift register
Counters- Design of Asynchronous and Synchronous Counters, mod – n counters, random counters, Ring Counter, Johnson Counter.

UNIT-3: SEQUENTIAL LOGIC DESIGN -II

Finite State Machines: Mealy and Moore model, State diagram, State table, State assignment, design synchronous sequential circuits, Examples like Sequence detector and traffic light control system

PRACTICES:

- Multiplexer & Demultiplexer
- Encoder & Decoder
- Code Converter
- Magnitude Comparator
- Parity generator/checker
- Flip flops
- Registers
- Counters
- Sequence Detector
- Design of any practical case study

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Module No.	Mappingwith POs
1	Apply knowledge of Boolean algebra and logic gates to design and simplify digital circuits.	Understand	1	1,2,3, 9,10
2	Apply minimization techniques to optimize switching functions.	Apply	1	1,2,3, 9,10
3	Design combinational circuits like adders, multiplexers, and decoders etc., for practical applications.	Apply	2	1,2,3,4,5, 6,7, 9,10
4	Develop sequential circuits using flip-flops, shift registers, and counters etc., for various digital systems.	Apply	2	1,2,3,4,5, 6,7, 9,10
5	Design finite state machine models to solve real-world problems like sequence detection and traffic control.	Apply	2	1,2,3,4,5, 6, 7, 9,10

SDGs **IKS**

SDG 7 (Affordable and Clean Energy)
SDG 8 (Decent Work and Economic Growth)
SDG 9 (Industry, Innovation, and Infrastructure)
SDG 11(Sustainable Cities and Communities)

TEXT BOOKS:

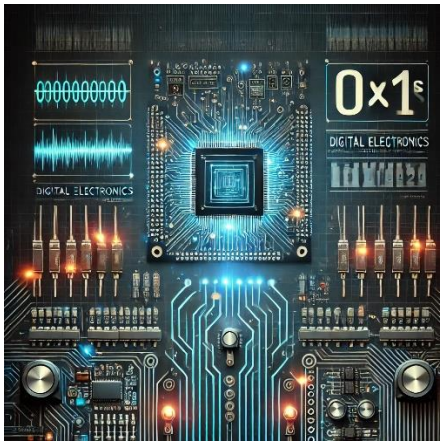
1. M. Morris Mano, “Digital Design”, 6th Edition, Pearson Education, 2018.
2. ZviKohavi, Niraj K. Jha, “Switching and Finite Automata Theory”, 3rd Edition, Cambridge University Press, 2009.

REFERENCE BOOKS:

1. John.M Yarbrough, “Digital Logic Applications and Design”, Thomson Learning, 2006.
2. Charles H.Roth. “Fundamentals of Logic Design”, 6th Edition, Thomson Learning, 2013.
3. Donald P.Leach and Albert Paul Malvino, “Digital Principles and Applications”, 6th Edition, TMH, 2006.

SKILLS:

- *Apply Boolean algebra techniques to simplify expressions*
- *Design efficient combinational digital circuits using gates, multiplexers, and decoders etc.*
- *Design efficient sequential digital circuits using flip flop.*
- *Implement and analyze finite state machines, shift registers, and counters to develop solutions for various digital applications.*



22ECXX – NETWORK THEORY

Hours per week:

L	T	P	SL	C
3	2	0	3	4

PREREQUISITE KNOWLEDGE: Knowledge on Algebra, calculus, and vectors.

COURSE DESCRIPTION AND OBJECTIVES:

The basic objective of this course is to introduce the fundamental theory and mathematics for the analysis of electrical circuits, frequency response and transfer function of circuits. The students will be able extend these fundamental principles into a way of thinking for problem solving in mathematics, science, and engineering

MODULE-1

18L+12T+0P+18SL=48 Hours

UNIT-1: INTRODUCTION TO CIRCUIT ELEMENTS

Source transformation, Voltage and current division, V-I characteristics of passive elements and their series / parallel combination, Energy stored in Inductors and capacitors, Kirchhoff's voltage law and Kirchhoff's current law, Mesh and nodal analysis, Star and delta conversions.

UNIT-2: NETWORK THEOREMS:

Superposition theorem, Thevenin theorem, Norton theorem, Maximum power transfer theorem, Reciprocity theorem, Compensation theorem, Analysis with dependent and independent current and voltage sources.

PRACTICES:

- Apply KVL and KCL
- Analyze different networks with dependent and independent sources
- Apply Mesh and Nodal analysis
- Analysis of different electrical circuits using theorems

MODULE-2

27L+18T+0P+27SL=72 Hours

UNIT-1: TRANSIENT ANALYSIS:

Solution of first and second order differential equations for Series and parallel R-L, R-C, R-L-C circuits, initial and final conditions in network elements, forced and free response, time constants, steady state and transient state response with DC excitation.

UNIT-2: TWO PORT NETWORKS:

Two Port Networks, terminal pairs, relationship of two port variables, impedance parameters, admittance parameters, transmission parameters and hybrid parameters, interconnections of two port networks.

UNIT-3: SINUSOIDAL STEADY STATE ANALYSIS:

Representation of sine function as rotating phasor, phasor diagrams, impedances and admittances, AC circuit analysis, effective or RMS values, average power and complex power. Resonance-Series and parallel resonance circuits, Concept of bandwidth and Q-factor.

PRACTICES:

- Transient response of RL, RC, RLC with different inputs
- Two port network parameters and inter relation
- Solving different two-port networks using Z, Y and ABCD parameters
- Find the response of the network for sinusoidal excitation

- Series RLC network
- Parallel RLC network

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Mapping with POs
1.	Apply Kirchhoff's laws and theorems to linear circuits.	Apply	1, 2, 4, 5, 8, 9, 11
2.	Analyze current and voltage behavior for the given circuit under transient conditions.	Apply	1, 2, 3, 5, 8, 9
3.	Analyze the given network using specified two port network parameter like Z or Y or T or h.	Analyze	1, 2, 3, 5, 8, 9
4.	Analyze the steady state response of RL, RC and RLC circuits and resonance.	Evaluate	1, 2, 3, 4, 5, 8, 9, 11

Mapping of SDGs and IKS

Sustainable Development Goals (SDGs)

SDG 9 (Industry, Innovation, and Infrastructure)
SDG 11 (Sustainable Cities & Communities)

TEXT BOOKS:

1. M. E. Van Valkenburg and TS Rathore "Network analysis", Prentice India Education Services Pvt.Ltd, 3rd edition, 2019.
2. A Sudhakar and Shyammohan S Palli, "Circuits & Networks: Analysis and Synthesis", 5th edition, Tata McGraw-Hill,2019.

REFERENCEBOOKS:

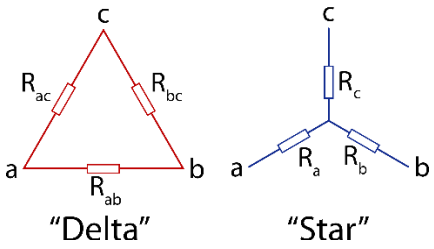
1.William H. Hayt, Jack E. Kemmerly and Steven M. Durbin, "Engineering Circuit Analysis", 7th edition,Tata McGraw-Hill,2007.
2.Franklin F.Kuo, "Network Analysis and Synthesis", 2nd Edition, John Wiley and Sons, 2003.
3.A Chakrabarthy, Electric Circuits‖, Dhanpat Rai & Sons, 6th Edition, 2010.
4.Mahmood Nahvi and Joseph Edminister, "Electric Circuits", 4th edition, Schaum's Outline series, Tata McGraw-Hill, 2004.

SKILLS:

- Understand different components and their characteristics.
- Able to analyze/ find responses using theorems.
- The behavior of RL/RC/RLC can be evaluated for different inputs.
- Able to analyze regulated power supply.

Image source: https:// en.m.wikipedia. org/wiki/ File:Delta-Star_ Transformation. svg

Image file name:



22EEXXX - ELECTRONIC DEVICES AND CIRCUITS

Hours per Week:

PREREQUISITE KNOWLEDGE:

- Semiconductor Physics
- Network Theory

L	T	P	SL	C
3	0	2	3	4

COURSE DESCRIPTION AND OBJECTIVES:

This course focuses on the design and analysis of various semiconductor devices, the basic principle of BJT and MOSFET amplifiers using suitable biasing techniques and to perform ac analysis. The operation and design of various power amplifier circuits, differential amplifier circuits, multistage amplifiers, tuned amplifiers and analyze its frequency response. Students will gain hands-on experience in analyzing and designing electronic circuits, understanding their behavior, and applying them to real-world problems.

MODULE-1

18L+0T+12P+18SL=48 Hours

UNIT-I: BIPOLAR JUNCTION TRANSISTOR

BJT Device structure and physical operation, Current-voltage relationship -CB,CE,and CC configuration -nonideal effects-Base width modulation-Ebers-Moll Model. Small Signal Model, Device Capacitance-Equivalent circuit model

UNIT-2: FIELD EFFECT TRANSISTOR

JFET, MOS Capacitors, Energy-band Diagram, flat-band, accumulation, depletion, inversion, Threshold voltage, capacitance-voltages characteristics. MOSFETS: Current-Voltage Characteristics, Velocity Saturation, Leakage currents, short channel effects- Vt roll-off and drain Induced barrier lowering, scaling limits

PRACTICES:

- Common Emitter Characteristics
- Common Base Characteristics
- BJT as a Switch
- JFET Characteristics
- MOSFET Characteristics

MODULE-2

27L+0T+18P+27SL=72 HOURS

UNIT-1: SINGLE AND MULTISTAGE AMPLIFIERS

Amplifier design and Analysis of CE, CC, CB, CE-CE, CE-CB, CE-CC, Darlington (CC-CC) amplifiers. Analysis of CS, CD, CG, CS-CS, CS-CG, CS-CD, Darlington (CD-CD) amplifiers.

UNIT-2: TUNED AMPLIFIERS

Introduction, Q-Factor, small signal tuned amplifier, characteristics of tuned amplifiers –single tuned and double tuned amplifier, stagger tuned amplifier and gain BW product

UNIT-3: POWER AMPLIFIERS

Operation and analysis of class A Power amplifier, Class B amplifier, push-pull amplifier and complementary symmetry power amplifier, Class AB power amplifier, class C amplifiers, and Class D amplifiers. Thermal stability and Heat sinks.

PRACTICES:

- Design and analysis of single stage amplifiers
- Design and analysis of multistage amplifiers
- Design and analysis of tuned amplifiers
- Design and analysis of power amplifiers.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	**Design** stable biasing circuits for BJT/MOSFET	Understand	1	1, 2, 3,4, 5,6,9, 10,11
2	Design the BJT and MOSFET amplifier circuits using suitable biasing techniques and analyze their frequency response characteristics.	Apply	1,2	1, 2, 3,4, 5,6,9, 10
3	**Design and analysis of** single and multistage amplifiers	Apply	2	1, 2, 3,4, 5,6,9, 10
4	**Analyse** various tuned and power amplifiers	Analyse	2	1, 2, 3,4, 5,6,9, 10

SDGs

SDG 7 (Affordable and Clean Energy)
SDG 9 (Industry, Innovation, and Infrastructure)
SDG 12 Responsible Consumption and Production

IKS

BOOKS AND REFERENCES

TEXT BOOK:

1. Millman and C.Halkias, Electronic Devices and Circuits, Tata McGraw Hill.,2010.

REFERENCES:

1. Boylestad & Nashelsky, Electronic Devices & Circuit Theory, 11th edition, Prentice Hall Of India (P) Ltd., 2013.
2. Adel S. Sedra. Kenneth C. Smith and Arun N. Chandorkar, “Micro Electronic Circuits: Theory and Applications”, 7th edition, Oxford University Press, 2017.
3. M.H. Rashid, “Micro Electronic Circuits: Analysis and Design”, 1st edition, Thomson PWS Publications, 1999.
4. Donald A. Neamen, Electronic Circuit Analysis and Design, 3e, Tata McGraw Hill, 2008

SKILLS:

- Developing the ability to systematically analyze existing circuits and creatively design new ones to meet specific functional requirements.
- Understanding the fundamental physics of MOSFET operation, including the formation of inversion layers and channel conductivity
- Gaining a comprehensive understanding of electronic component characteristics and developing the skill to select and apply them effectively
- Designing MOSFET-based switching circuits for power control and signal switching.

22ECXXX COMPUTER ARCHITECTURE AND ORGANIZATION

Hours per week:4

L	T	P	SL	C
2	2	2	2	4

PREREQUISITE KNOWLEDGE: Basics of Computers, Digital Electronics.

COURSE DESCRIPTION AND OBJECTIVES:

This course covers fundamental and advanced concepts of computer architecture, including instruction set design, CPU organization, memory hierarchy, I/O systems, and touches modern computing paradigms like parallel and quantum computing. The aim is to get an insight about the functioning of computers and evaluate their performance metrics.

MODULE-1

12L+12T+12P+12SL=48 Hours

UNIT-1: STRUCTURE OF COMPUTERS

Introduction: History of computers; Von-Neumann, Harvard, Super Harvard architectures, Computer components, Computer Function.

Instruction Set Architecture (ISA): The Evolution of the Intel x86 Architecture, ARM Architecture, CISC Vs RISC; Designing for performance.

UNIT-2: COMPUTER ARITHMETIC AND CPU

Computer Arithmetic: Integer representation, Integer arithmetic, Floating-point representation, IEEE Standard 754, Floating-point arithmetic.

Instruction Sets: Address format, Instruction format, Types of operands, Intel x86 and ARM data types, Types of operations, and Addressing modes.

CPU Implementation: Processor organization, Register organization, Stack organization, Hardwired logic, Micro programmed logic.

PRACTICES:

- Arithmetic and Logic Micro-Operations.
- Integer arithmetic.
- Single precision representation in IEEE Standard 754.
- Floating point arithmetic.
- Instruction sets and addressing modes of 8086.

MODULE-2

18L+18T+18P+18SL=72 Hours

UNIT-1: MEMORY ORGANIZATION

Memory: Internal memory - RAM, ROM; External memory - Magnetic disk, RAID, Cache memory, Mapping techniques.

UNIT-2: I/O ORGANIZATION AND MULTIPROCESSORS

Input/Output: Memory-mapped I/O, Isolated I/O, Programmed I/O, Interrupt driven I/O, DMA. Pipeline: Arithmetic pipeline, Instruction pipeline, RISC pipeline, Multiprocessors: Characteristics of multiprocessors, Interconnection structures.

UNIT-3: CONTROLLERS

Overview of ARM architecture, Features and versions of ARM processors, Introduction to ARM Cortex-M series, Instruction set: Data movement, arithmetic, logic, program flow. Features and architecture of STM32 microcontrollers, Memory Organization and Peripherals in STM32.

PRACTICES:

- Memory interface with 8086.
- Mapping techniques.
- Cache performance.

- I/O communication.
- IN/OUT instructions of 8086.
- Interfacing of 8086 with 8225.
- Flynn's taxonomy.
- Introduction to Visio/edraw/Verilog.
- Introduction to Keil uVision 4 software.
- 8-bit, 16-bit, 32 bit Arithmetic and Logical operations.
- Searching a number, Find and replace the number in a given array.
- Find the smallest/largest number, Arrange the given numbers in sorting order.
- Block transfer using load/store instructions.
- Blinking of LEDs in port 0 or port 1 in LPC2148.
- Read the input from one port and display into output port using LPC2148.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Mapping with POs	Relevant SDGs
1.	Explain the fundamental structures of computers, including Von-Neumann and Harvard architectures.	Remember, Understand	1, 2	4
2.	Analyze and compare instruction set architectures (CISC, RISC) and their impact on processor performance.	Understand, Analyze	2, 3	9
3.	Apply concepts of computer arithmetic and CPU organization to design and evaluate processor functionality.	Analyze, Evaluate	3, 5	8
4.	Examine memory organization techniques, including cache mapping, RAM, ROM, and RAID storage.	Understand, Apply	2, 4	12
5.	Investigate I/O mechanisms, pipeline processing, and multiprocessor architectures for performance optimization.	Analyze, Apply	4, 6	9
6.	Explore ARM-based microcontroller architectures, including STM32, for embedded system applications.	Understand, Evaluate	5, 7	11

TEXT BOOKS:

1. William Stallings, "Computer Organization & Architecture: Designing for Performance", 11th Edition, Pearson, 2019.
2. Steve Furber, "ARM System on Chip Architecture", 2nd edition, Pearson education, 2014.

REFERENCEBOOKS:

1. Linda Null, "Essentials of Computer Organization and Architecture", Jones & Bartlett Publishers, 6th Edition, 2024.
2. Sajjan G. Shiva, "Computer Organization, Design, and Architecture", 5th Edition, CRC Press, Taylor & Francis, 2014.

3. Jim Ledin, “Modern Computer Architecture and Organization”, 2nd edition, Packt Publishing, 2022.
4. William Hohe and Christopher Hinds, “ARM Assembly Language: Fundamentals and Techniques”, 2nd edition, CRC Press, 2015.
5. “LPC214x User Manual (UM10139)”, Volume 1, Philips Semiconductors, 2015. (https://www.nxp.com/docs/en/user-guide/UM10139.pdf)

SKILLS:

- Grasp computer architecture concepts, instruction set design, and system components like ALU, registers, and control units.
- Analyze memory hierarchy, cache mapping, virtual memory, I/O architectures, and system performance.
- Compare von Neumann vs. non-von Neumann models, CISC vs. RISC architectures, and study instruction execution cycles.
- Explore Flynn’s Taxonomy, multiprocessor architectures, parallel computing models, and real-world applications.
- Develop parallel processing programs, analyze performance efficiency, and understand future trends like quantum computing, and neuromorphic computing.
- Identify suitable hardware components for a specific application.
- Design a microcontroller-based system using LPC 2148.
- Develop the environment for interfacing peripherals with ARM processors.
- Develop Embedded-C or Assembly language programs using LPC 2148.

22ECXXX – FPGA BASED SYSTEM DESIGN

Hours per week:

L	T	P	SL	C
2	2	2	2	4

PREREQUISITE KNOWLEDGE: Digital Electronics.

COURSE DESCRIPTION AND OBJECTIVES:

This course covers the advanced design and analysis of digital circuits with HDL. The primary goal is to provide in depth understanding of system design. The course enables students to

apply their knowledge for the design of advanced digital hardware systems with help of FPGA tools.

MODULE-1

12L+12T+12P+12SL=48 Hours

UNIT-1: OVERVIEW OF FPGA ARCHITECTURES AND TECHNOLOGIES

Introduction to programmable logic devices- PAL, PLA, PLD, CPLD, FPGA

The role of FPGA in digital design, FPGA types, FPGA Vs Custom VLSI, FPGA Architectures, SRAM based FPGAs, Antifuse based FPGAs, EPROM based FPGAs, case study of any one FPGA board.

UNIT-2: VERILOG HDL CODING STYLES -1

Verilog HDL: Emergence of HDLs, importance of HDLs, Design flow, Hierarchical Modeling Concepts, Lexical conventions, Ports and modules, data types, System tasks and Compiler directives,

Gate level modelling – Gate types and primitives, gate delays, User defined primitives, Examples.

PRACTICES:

- Logic gates
- Adder, Subtractor
- Multiplexer, Demultiplexer
- Encoder, Decoder
- Magnitude Comparator
- Flip flops

MODULE-2

18L+18T+18P+18SL=72 Hours

UNIT-1: VERILOG HDL CODING STYLES -2

Data flow modelling style - Continuous assignments, Operators, Delays structures, Examples

switch level modelling style – MOS Switches, CMOS switches, Bi-directional switches, Resistive switches, Delay specification on switches, examples.

UNIT-2: VERILOG HDL CODING STYLES -3

Behavioral level Modeling style: Structural procedures, procedural constructs, Timing controls, conditional statements, multiway branching, loops, sequential and parallel blocks, generate blocks, examples, tasks and functions, procedural continuous assignments.

UNIT-3: MODELING AND SYNTHESIS

Modeling: Behavioral, Data flow and structural realization – Adders, Multipliers, Flip-Flops, Shift registers, Synchronous and asynchronous counters, Pseudo random LFSR, sequence detector FSM.

Logic Synthesis with Verilog HDL: Introduction and impact of logic synthesis, Verilog HDL synthesis, synthesis design flow, an example of RTL to Gates.

PRACTICES:

- Code converter
- Serial adders/Parallel adders
- Flipflops
- Shift registers

- Counters
- Sequence detector

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Module No.	Mappingwith POs
1	Understand the fundamentals of FPGA architectures, programmable logic devices, and their role in digital design.	Understand	1	1,2,3, 9,10
2	Explore the fundamentals of Verilog HDL, including its emergence, significance, design flow, and key constructs for digital circuit modeling.	Understand	1	1,2,3,5, 9,10
3	Develop Verilog HDL models using gate-level, data flow, switch-level, and behavioral modeling techniques.	Apply	2	1,2,3,4,5, 6,7, 9,10
4	Design combinational and sequential circuits such as adders, multiplexers, flip-flops, and counters etc., using Verilog HDL.	Apply	2	1,2,3,4,5, 6,7, 9,10
5	Synthesize the FSM-based digital systems, including sequence detectors and pseudo-random LFSRs etc., for practical applications.	Apply	2	1,2,3,4,5, 6, 7, 9,10

SDGs

SDG 8 (Decent Work and Economic Growth)

SDG 9 (Industry, Innovation, and Infrastructure)

SDG 11(Sustainable Cities and Communities)

SDG 12 (Responsible Consumption and Production)

IKS

TEXT BOOKS:

1. Stephen Brown & ZvonkoVranesic, “Digital Logic Design with Verilog HDL” TATA McGraw Hill Ltd. 2nd Edition 2007.
2. Samir Palnitkar, “Verilog HDL: A Guide to Digital Design and Synthesis” Prentice Hall, Second Edition, 2003.
3. Wayne Wolf, “FPGA Based System Design”, PTR Prentice Hall, 2004.

REFERENCES BOOKS:

1. T.R. Padmanabhan, B.Bala Tripura Sundari, “Design through Verilog HDL” Wiley Interscience, 2004.
2. S. Ramachandran, “Digital VLSI System Design: A Design Manual for implementation of Projects on FPGAs and ASICs Using Verilog” Springer Publication, 2007.
3. Clive Maxfi eld, “The Design Warriors’s Guide to FPGAs”, Elsevier, 2004.
4. Peter Ashenden, “Digital Design using Verilog”, Elsevier, 2007.

SKILLS:

- Implementing digital circuits using different modeling styles using Verilog HDL Coding.
- Designing combinational and sequential circuits on FPGA.
- Simulation & Debugging can be done using EDA tools for testing and optimization.

22EC3XX – CONTROL SYSTEMS

Hours per week:

L	T	P	SL	C
2	2	0	2	3

PREREQUISITE KNOWLEDGE: Basics of circuit theory, differentiation, complex numbers and Laplace transform.

COURSE DESCRIPTION AND OBJECTIVES:

This course focuses on how to obtain mathematical model of any physical system. To be able to do time-domain and frequency-domain analyses of the model to predict the system's time response, frequency response and stability and to design control systems to meet the given stability specifications.

MODULE-1

12L+12T+0P+12SL=36 Hours

UNIT-1: MATHEMATICAL MODELING OF CONTROL SYSTEMS

Motivation, Concept of control systems, classification of control systems, Transfer function, block diagram and signal flow graph representation of electrical systems, basic idea of feedback control systems, block diagram algebra and Mason's gain formula to obtain over all transfer function.

UNIT-2: TIME RESPONSE ANALYSIS AND CONTROLLERS

Time response analysis for first and second order systems, transient and steady state response, time domain specifications: rise time, peak time, peak overshoot, settling time, steady state error. Effect of Proportional, Proportional and Integral, Proportional and Derivative , Proportional Integral and Derivative controllers.

PRACTICE:

- Determine systems that can be modeled by Ordinary Differential Equations (ODEs)
- Obtaining overall transfer function for given electric circuits, block diagrams and signal flow graphs.
- Analyze time domain specifications to understand system behavior.
- Calculate Steady state error of a system for given input.
- Analyzing which controller is suitable to meet the given specifications.

MODULE-2

18L+18T+0P+18SL=54 Hours

UNIT-1: STABILITY ANALYSIS

Routh-Hurwitz test to find stability, Limitations of Routh-Hurwitz stability criterion, root-locus technique, steps in obtaining a root-locus, Stability analysis using Root locus, Effect of adding poles and zeros on stability using root locus.

UNIT-2: FREQUENCY DOMAIN STABILITY ANALYSIS AND COMPENSATORS

Bode plots, Stability analysis using Bode plots, polar plot, Nyquist stability criterion. Effect of Lead, Lag, Lead-Lag compensators.

UNIT-3: STATE SPACE ANALYSIS OF LINEAR TIME INVARIANT SYSYEM

Concepts of state - state variables and state model - state space representation of transfer function - diagonalization using linear transformation - solving the time invariant state equations - State Transition Matrix and its properties- concepts of controllability and observability.

PRACTICE:

- Analyzing which compensator is suitable to meet the given specifications.
- Determine the closed loop system's stability using R-H criterion.
- Stability analysis with the help of root locus.
- Stability analysis with the help of Bode plots.
- Stability analysis with the help of Nyquist stability criteria.
- Represent physical systems as state models and determine the response.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Mapping with POs

1.	Obtain the overall transfer function of a given system	Apply	1, 2, 8,9
2.	Analyze the importance of controllers and compensators to improve the system's performance	Analyze	1, 2, 8, 9
3.	Analyze the time response of a given system	Analyze	1, 2, 4, 8, 9
4.	Analyze the stability of a given system	Analyze	1, 2, 4, 8, 9
5	Represent physical systems as state models and determine the response.	Analyze	1, 2, 4, 8, 9

Mapping of SDGs and IKS

Sustainable Development Goals (SDGs)	**Indian Knowledge Systems**
SDG 9 (Industry, Innovation, and Infrastructure)	
SDG 11 (Sustainable Cities & Communities)	
SDG 12 (Responsible Consumption and Production)	**NO**
SDG 13 (Climate Action)	

TEXT BOOKS:

3. J. Nagrath and M. Gopal, "Control Systems Engineering", 7th edition, New Age International

REFERENCEBOOKS:

6. Benjamin C Kuo and Farid Golnaraghi, "Automatic Control systems", 9th edition, Prentice Hall
7. Katsuhiko Ogata, "Modern Control Engineering", 5th edition, Prentice Hall of India Private Ltd,New Delhi, 2020.

SKILLS:

- Model the given electrical and electronic circuits with equations, block diagrams and signal flow graphs.
- Obtain over all transfer function of any given block diagram and signal flow graph.
- Analyze the controllers and compensators for given specifications.
- Analyze the transient and steady state response of a given system.
- Analyze the stability of a system with different tools like RH criterion, Root locus, Bode plots and Nyquist plots.

Image source:
https://www.tutorialspoint.com/control_systems/control_systems_introduction.htm

Image file name: CONTROL SYSTEMS

22ECXXX– ELECTROMAGNETIC WAVES AND TRANSMISSION LINES

Hours per week:

L	T	P	SL	C
2	2	2	1	4

PREREQUISITE KNOWLEDGE: Basics Physics, Multivariable calculus and vector analysis

COURSE DESCRIPTION AND OBJECTIVES:

This course offers the fundamental knowledge of electromagnetic fields involving in various engineering applications. It gives the foundation in electromagnetic waves and Transmission lines and its use in modern communication areas such as wired and wireless. The objective of the course is to enable the student familiarize with the propagation, reflection, and transmission of plane waves in bounded and unbounded media, transmission lines and waveguides.

MODULE-1

12L+12T+0P+12SL=36 Hours

UNIT-1: ELECTROSTATIC, MAGNETOSTATIC FIELDS AND MAXWELL'S EQUATIONS

Review of coordinate systems and vector analysis.
Electrostatic Fields: Coulomb's law, Gauss's law, Boundary conditions, Poisson's and Laplace's equations.
Magnetostatic Fields: Biot-Savart law, Ampere's Circuital law, Magnetic boundary conditions, Self-inductance and mutual inductance.
Maxwell's equations: Faraday's law, Displacement current, point form and integral form, Uniform plane wave equation**.**

UNIT-2: WAVE EQUATIONS WAVE PROPAGATION IN DIFFERENT MEDIA

Wave equations: Helmholt'z Wave Equations, Wave Equations in Free space, good dielectrics and good conductors medium, Skin depth, Wave polarization.

Wave Propagation in Different Media: Normal incidence of waves on perfect conductor and dielectric, Oblique incidence of waves on perfect conductor and dielectric, Poynting theorem and Poynting vector.

PRACTICES:

1. Generate Electromagnetic Wave using MATLAB software.
2. Verification of Maxwell equation.
3. Experiments on tracing of electric and magnetic flux lines for standard configuration
4. Calculation of wave propagation in free space and conducting medium
5. Generation of different wave polarization using HFSS/CST/ADS

MODULE-2

18L+18T+0P+18SL=54 Hours

UNIT-3: TRANSMISSION LINES
Transmission Lines : Equations of voltage and current on TX line, Propagation constant and characteristic impedance, Reflection coefficient and VSWR, Impedance transformation on loss less and low loss transmission line.
UHF lines : λ/4, λ/2, λ/8 lines, Smith Chart, Smith chart as impedance chart, smith chart as admittance chart, Problems using smith chart. Impedance matching, Quarter wave transmission line, impedance matching.

UNIT-4: PLANAR TRANSMISSION LINES

Characteristics Planar transmission lines: Introduction, Strip Lines
Micro strip Lines : Shielded Microstrip Line, Characteristic Impedance of the Microstrip Line, Effects of Finite Strip Thickness in Microstrip Lines, Attenuation in Microstrip Lines, Choosing Physical Dimensions for Microstrip Applications.
Suspended Stripline, Slotline, Coplanar Waveguide, Finline.

UNIT-4: DISTRIBUTED AND LUMPED ELEMENTS OF INTEGRATED CIRCUITS
Introduction: Capacitors , Inductors, Print Inductors Consideration, Dual-Spiral, Resistors, Terminations and Attenuators ,Resonators, Discontinuities .

PRACTICES:

1. Calibrate the Network Analyzer for Transmission line.
2. Study the characteristics of a series RC and RL Circuit.
3. Verification Scattering parameters using Smith chart.
4. Design of λ/4, λ/2, λ/8 TX lines
5. Design of Strip Lines, Mirostriplines and CPW.
6. Design of Capacitors , Inductors, Print Inductors using HFSS/ CST and ADS

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs	Mapping with SDGs
1	**Analyze** Maxwell's equation in different forms (differential and integral) and apply them to diverse engineering problems of electromagnetic wave propagation.	Analyze	1	1, 2, 4,5, 9, 10,11	SDG 9 (Industry, Innovation, and Infrastructure)
2	**Understand** the phenomena of wave propagation in different media. Illustrate the concepts of electro-magnetic wave propagation and wave characteristics.	Understand	2	1, 2,4,5, 9, 10,11	SDG 7 (Affordable and Clean Energy), SDG 9
3	**Analyze** the characteristics of transmission lines and solve the parameters using smith chart.	Analyze	2	1, 2,3,4,5, 9, 10, 11	SDG 9, SDG 12 (Responsible Consumption and Production)
4	**Analyze** the basic concept and characteristics of planar transmission lines and distributed and Lumped Elements of Integrated Circuits.	Understand the basic concept of patch antenna and	2	1, 2,3,4,5, 9, 10, 11	SDG 9, SDG 11 (Sustainable Cities and Communities)

TEXT BOOKS:

1. Matthew N.O. Sadiku, "Elements of Electromagnetics", 3rd edition, Oxford Univ. Press,2001.
2. David M. Pozar, "Microwave Engineering", 4th edition, John Wiley and Sons, 2012.
3. Maloratsky, L., 2003. Passive RF and microwave integrated circuits. Elsevier.

REFERENCEBOOKS:

1. William H. Hayt and John A. Buck, 'Engineering Electromagnetics', McGraw Hill Special Indian edition, 2014.
2. Jordan, E.C. and Balmain, K.G., 1968. Electromagnetic waves and radiating systems. Prentice-Hall.
3. Kraus and Fleish, 'Electromagnetics with Applications', McGraw Hill International Editions, Fifth Edition, 2010.
4. E.V.D. Glazier and H.R.L. Lamont, Transmission and Propagation, The Services Text Book of Radio, vol. 5, Standard Publishers Distributors, Delhi.
5. Joseph. A.Edminister, 'Schaum's Outline of Electromagnetics, Third Edition (Schaum's Outline Series), McGraw Hill, 2010.
6. S.P.Ghosh, Lipika Datta, 'Electromagnetic Field Theory', First Edition, McGraw Hill Education(India) Private Limited, 2012.
7. J.D.Kraus and Ronald J Marhefka, "Antennas and Wave propagation", 4th edition,

TMH, 2014.
8. Edward C Jordan and Keith G Balmain, "Electromagnetic Waves and Radiating Systems", 2nd edition, PHI, 2003

SKILLS:

- Study and analyse final form of Maxwell equations, the behaviour of the electric field across a boundary between a conductor and dielectric and between two different dielectrics.
- Study the time-varying fields and propagation of waves in different media.
- Analyze the transmission line impedance parameters.

22ECXXX –CMOS VLSI Design

Hours per week:

L	T	P	SL	C
3	0	2	3	4

PREREQUISITE KNOWLEDGE: Electronics Components and Devices.

COURSE DESCRIPTION AND OBJECTIVES:
VLSI design course deals with understanding of the basic electrical properties characteristics of CMOS circuit construction and also introduce the concepts and techniques of fabrication.

MODULE-1

18L+0T+12P+18SL=48 Hours

UNIT-1: VLSI DESIGN and CMOS Processing Technology
VLSI Design flow, Design domains, hierarchy, regularity, modularity, locality, VLSI design styles, design capture tools, simulation, synthesis, physical design, testing -BIST,
Introduction to the basic fabrication processes - wafer preparation, oxidation, lithography, diffusion, ion implantation, etching, metallization, Fabrication process Flow: nWell, pWell, Twin tub and Silicon on insulator process.

UNIT-2: ELECTRICAL CHARACTERISTICS OF MOS TRANSISTOR

MOS Transistor Introduction: nMOS and pMOS Transistor Operation, Ids-Vds Relationship, Channel Length Modulation, Transistor Parameters - Threshold Voltage, Body Effect, Transconductance, Output Conductance, Figure Of Merit. NMOS inverter, CMOS Inverter, BiCMOS Inverter.

PRACTICES:

- Characteristics of MOSFET
- nMOS inverter
- CMOS Inverter
- BiCMOS Inverter

MODULE-2

27L+0T+18P+27SL=72 Hours

UNIT-1: Digital VLSI Design

Static CMOS Logic gates: Static CMOS NAND, NOR, AND, OR, EXOR, XNOR, AOI and OAI logic gates

Alternate CMOS logic structures – Pseudo NMOS logic, dynamic CMOS logic, clocked CMOS logic, domino CMOS logic and DCVS logic, Pass transistor, Transmission gate logic, Power dissipation.

Sub system Design: 1-bit adder, array multiplier, latches and flip-flops

UNIT-2: Analog VLSI design

CMOS Analog circuits: Single stage Amplifiers: Common-source stage, Source follower, Common-gate, Differential Amplifiers, current mirrors, op-amp.

UNIT-3: VLSI Circuit Design Processes

MOS Layers, Stick Diagrams, Design Rules and Layout, Transistors Layout Diagrams for NMOS and CMOS Inverters and Gates, Scaling of MOS circuits.

PRACTICES:

- Simulation of logic gates using Pseudo nMOS logic.
- Simulation of logic gates using Dynamic logic.
- Simulation of 1-bit adder.
- Simulation of flipflops.
- Simulation of CS Amplifier
- Simulation of CG Amplifier
- Simulation of CD Amplifier
- Simulation of differential Amplifier
- Simulation of current mirror
- Design of CMOS Inverter Layout

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Module No.	Mappingwith POs
1	Understand the VLSI design flow, design methodologies, and fabrication processes involved in semiconductor manufacturing.	Understand	1	1, 2, 3, 9, 10

2	Apply the principles of MOS transistor operation to analyze electrical characteristics such as threshold voltage, transconductance, and channel length modulation	Apply	1	1, 2, 4, 5, 9, 10
3	Analyze different CMOS ombinational and sequential digital VLSI subsystems structures, including static and dynamic logics, for their power efficiency and performance in VLSI design.	Analyze	2	1, 2, 3, 4, 5, 9, 10
4	Design CMOS-based analog circuits, including amplifiers, current mirrors, and operational amplifiers, for integrated circuit applications	Apply	2	1, 2, 3, 4, 5, 6, 9, 10
5	Develop VLSI circuit layouts using stick diagrams, design rules, and transistor-level layout techniques for optimized performance and scalability.	Apply	2	1, 2, 3, 4, 5, 6, 9, 10

SDGs **IKS**

SDG 8 (Decent Work and Economic Growth)

SDG 9 (Industry, Innovation, and Infrastructure)

SDG 11(Sustainable Cities and Communities)

SDG 12 (Responsible Consumption and Production)

TEXT BOOKS:

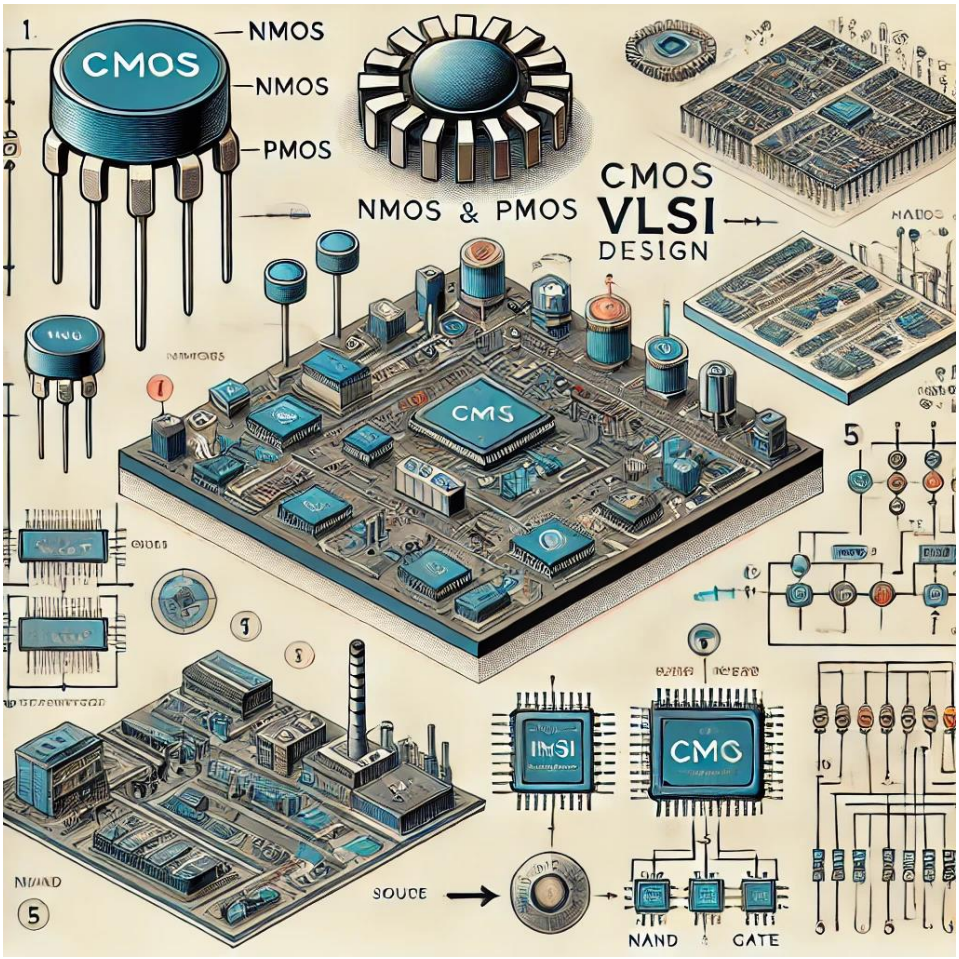
1. Neil H. Weste and Kamaran Eshranghian,, "Principles of CMOS VLSI Design: Systems perspective", Pearson, reprint, 4th edition, 2022
2.Douglas A Pucknell and Kamran Eshranghian, "Essentials of VLSI Circuits and systems", 3rd edition, Prentice Hall of India, 2011.
3. Behzad Razavi, Design of Analog CMOS Integrated Circuits, 2nd Edition, McGraw Hill Education, 2016.

REFERENCE BOOKS:

1. S.M. Sze, "VLSI Technology", 2nd edition, TMH, 2007.
2. Amar Mukherjee, "Introduction to nMOS and CMOS VLSI System Design", 1st edition, Prentice Hall, 1986.
3. Ajay Kumar Singh, "Digital VLSI Design", 1st edition, PHI Learning Private Limited, 2011.

SKILLS:

- Understand the VLSI Design and semiconductor manufacturing processes.
- Design efficient digital and analog circuits Circuits..
- Using EDA tools for circuit simulation, verification, and creating optimized VLSI layouts.



22EVXXX – SCRIPTING LANGUAGES

Hours per week:

L	T	P	SL	C
2	0	2	2	3

PREREQUISITE KNOWLEDGE: Basic concepts of computer programming.

COURSE DESCRIPTION AND OBJECTIVES:
This course explains the characteristics and uses of scripting languages. It also explains the way to use concepts of Perl & TCL in VLSI design.

MODULE-1

12L+0T+12P+12SL=36 Hours

UNIT-1: INTRODUCTION TO SCRIPTING LANGUAGE USING PERL

Characteristics and uses of scripting languages, Introduction to PERL, Names and values, Variables and assignment, Scalar expressions, Control structures, Built-in functions, Collections of Data, working with arrays, Lists and hashes.

UNIT-2: ADVANCED PERL

Subroutines, working with files, Navigating the file system, Type globs, Eval, References, Packages, Libraries and modules, Arrays of Arrays, Hashes of arrays, Perl in VLSI design.

PRACTICES:

- Set up a Perl development environment for practicing Perl.
- Understanding of variables, data types and loops in Perl.
- Take a string input from the user and print the reversed string in Perl.
- Take two numbers as input and perform basic arithmetic operations (addition, subtraction, multiplication, division) in Perl and TCL.
- Calculate and print the factorial of a number provided by the user in Perl & TCL.
- Take input from the user and concatenate it with a pre-defined string, then print the result in Perl & TCL.

MODULE-2

18L+0T+18P+18SL=54 Hours

UNIT-1: INTRODUCTION TO TCL

Evolution of TCL, TCL structure, Key features of TCL, Syntax, Data types, Variables, Operators, Loops, Arrays, Working with Strings, Procedures, Namespaces, Regular Expressions.

UNIT-2: ADVANCED TCL

Files and Pipes, Libraries and packages, Event-driven programs, Sockets, network programming in TCL, 'Nuts- and-bolts' in internet programming, Security issues, TCL in VLSI design automation, switching assignments to another VLSI project.

UNIT-3: Tk TOOLKIT FOR GUI PROGRAMMING

Introduction to Tk, Tk Widgets like button, level, entry, text, layout management pack, grid, place, Event handling, menus & dialogs.

PRACTICES:

- Write a program that takes user input and writes it to a file, then reads and displays the file contents in Perl.
- Take a list of numbers from the user, sort them in ascending or descending order, and print the sorted list in Perl.
- Write a program that accepts a string and a regular expression from the user, then finds and prints all matches in Perl.
- Write a Perl program to send an email using an SMTP server.
- Read from a file, display the contents, and write new data to a file in TCL
- Write a procedure to calculate the factorial of a given number in TCL.
- Create a simple TCP client and server that can exchange messages.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Mapping with POs	Relevant SDGs
1.	To identify basic Perl constructs and to outline Perl debugging commands.	Remember, Understand	1, 2	4
2.	To create and design simple Perl programs with the available Perl pre-defined functions.	Apply, Create	3, 5	9

3.	To demonstrate Perl subroutines and Perl references.	Understand, Apply	2, 4	4, 9
4.	Develop server-side scripts using Perl and TCL.	Apply, Analyze	5, 6	8, 9
5.	Create software systems using scripting languages, including Perl and TCL.	Create, Evaluate	7, 11	11, 12

TEXT BOOKS:

4. David Barron, "The World of Scripting Languages", Wiley Student Edition, 2021.

REFERENCEBOOKS:

8. Nathan Metzler, "Perl Programming for Beginners", 3rd Edition, Kindel, 2020.
9. Tom Christiansen, Brian D Foy, Larry Wall, Jon Orwant, "Programming Perl", O'Reily, 3rd Edition, 2010.
10. John Ousterhout, "TCL and the TK Toolkit", 2nd Edition, Kindel Edition, 2009.

SKILLS:

- Understanding the scripting languages basics and programming.
- Developing proficiency in writing TCL scripts for automation, system administration, and application development.
- Provide hands-on experience with practical applications using TCL and Tk toolkit for GUI development.
- Use of TCL in VLSI system design.

Image source:

https://www.google.com/url?sa=i&url=https%3A%2F%2Fmedium.com%2F%40mayurkoshti12%2Fworking-with-apis-in-perl-a-step-by-step-guide-28b5cd5a9111&psig=AOvVaw2lbGQZCdc88plRmwsp1rni&ust=1741433070389000&source=images&cd=vfe&opi=89978449&ved=0CBQQjRxqFwoTCJicoNbu94sDFQAAAAAdAAAAABAS

Image file name: Perl & TCL Programming (*Should be the course name*)

22VLXXX – MICROCHIP FABRICATION TECHNOLOGY

L	T	P	SL	C
3	2	0	3	4

PREREQUISITE KNOWLEDGE: VLSI Design

COURSE DESCRIPTION AND OBJECTIVES:

The course is intended to provide an understanding of current fabrication practices used in the semiconductor industry, along with the challenges and opportunities in device fabrication

MODULE-1

12L+12T+0P+12SL=36 Hours

UNIT-1: ENVIRONMENT FOR VLSI TECHNOLOGY

Brief History of Semiconductor technology, Scaling Trends and Scaling Methodologies, Scaling Challenges. Clean room and safety requirements. Wafer cleaning processes. Impurity incorporation: Solid State diffusion modelling and technology; Ion Implantation modelling and technology, damage annealing. Emerging trends in semiconductor materials structure, properties and doping techniques.

UNIT-2: OXIDATION AND LITHOGRAPHY

Oxidation: Kinetics of Silicon dioxide growth for thick, thin and ultrathin films. Oxidation technologies in VLSI and ULSI; Characterizations of oxide films; High k and low k dielectrics for ULSI. Lithography: Photolithography, E-beam lithography. Mask generation. Advanced lithography methods.

MODULE-2

18L+18T+0P+18SL=54 Hours

UNIT-1: DEPOSITION REQUIREMENTS AND TECHNIQUES-I

Physical vapor deposition (PVD) techniques: Evaporation - Thermal evaporation, Electron beam evaporation, Sputtering - Magnetron sputtering, Ion beam sputtering. Chemical vapor deposition (CVD) techniques: Photo assisted CVD, Thermally activated CVD, Plasma-enhanced CVD (RF, μ-Wave), Low-pressure CVD (LPCVD), Atmospheric-pressure CVD (APCVD).

UNIT-2: DEPOSITION REQUIREMENTS AND TECHNIQUES-II

Epitaxial growth techniques: Vapor-phase epitaxy (VPE), Molecular beam epitaxy (MBE), and Liquid-phase epitaxy (LPE). Wet and dry etching techniques: Wet etching chemistry, Plasma etching, Reactive ion etching (RIE), Deep reactive ion etching (DRIE). Etch requirements: Selectivity, anisotropy, and uniformity. Emerging deposition techniques: Atomic layer deposition (ALD) and its applications in high-k dielectrics and nanostructures. Wet and dry etching techniques, Etch requirements.

UNIT-3:INTERCONNECT TECHNOLOGY AND ADVANCED PROCESS FLOWS

CMOS and BJT process flow: Key steps and integration challenges. CMOS process for sub-100nm era: Low-k dielectrics with copper interconnects: Integration challenges and solutions. Strained silicon and silicon-germanium: Process techniques to overcome short-channel effects: Nanolithography techniques: multi-patterning and directed self-assembly. SOI technology: Fabrication and advantages for low-power applications.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1.	Apply and analyze the fabrication processes such as Etching, Deposition, and Epitaxy	Apply	1,2	1, 2, 3,4, 5, 9, 10.
2.	Prepare, characterize and analyze the samples with suitable techniques	Apply	1,2	1, 2, 3,4, 5, 9, 10.
3.	Comprehend and apply concepts related to interconnects and metallization, process flow, and integration with CMOS Technology	Analyze	2	1, 2, 3,4, 5, 9, 10.

SDGs	IKS
SDG 7 (Affordable and Clean Energy)	Eco-friendly material processing (natural etchants, purification methods).
SDG 9 (Industry, Innovation, and Infrastructure)	
SDG 12 (Responsible Consumption and Production)	Advanced material knowledge (ancient metallurgy for semiconductor alloys).
SDG 13 (Climate Action)	

TEXT BOOKS:

1. Peter Van Zant, "Microchip Fabrication: A Practical Guide to Semiconductor Processing", McGraw-Hill Professional, Sixth Edition, 2014.

REFERENCE BOOKS:

1. Gary. S. May and S. M. Sze, “Fundamentals of semiconductor fabrication”, John Wiley, First Edition, 2003.
2. Marc J. Madou, “Fundamentals of Microfabrication and Nanotechnology - Volume II”, CRC Press, Third Edition, 2011.
3. Stephen Campbell, “Science of Microelectronic Fabrication”, Oxford University Press, 2001. James D. Plummer, Michael D. Deal, Peter B. Griffin, “Silicon VLSI Technology: Fundamentals, Practice and Modeling”, Prentice Hall India Private Limited, 2000

SKILLS:

- Know various deposition techniques at the atomic and molecular level.
- Acquire knowledge about the structure and properties of thin films.
- Learn the advanced concepts in various vapour deposition techniques.
- Be aware of various morphological techniques and selecting appropriate tools for their future research.

Department Elective

22XXXXX – VERIFICATION USING SYSTEM VERILOG

Hours per week:

L	T	P	SL	C
3	0	2	3	4

PREREQUISITE KNOWLEDGE: Digital Electronics, FPGA based System Design.

COURSE DESCRIPTION AND OBJECTIVES:

To expose students to all aspects of functional verification of digital systems, with a focus on verifying hardware designs using a practical, hands-on approach. The course aims to introduce FPGA-based verification and emulation of VLSI systems, while also covering the foundational concepts of System Verilog and Object-Oriented Programming (OOP).

MODULE-1

18L+0T+12P+18SL=48 Hours

UNIT-1: BASICS OF SYSTEM VERILOG

Importance of functional verification in digital systems, Verification methodologies: Directed vs. Constrained-random verification, Verification flow and testbench components, Introduction to System Verilog for verification, Data Types, Arrays, Structures, Unions, Procedural Blocks, Tasks & Functions, Procedural Statements, Interfaces.

UNIT-2: Object-Oriented Programming (OOP) in SystemVerilog

Introduction to classes and objects in System Verilog, Class properties, methods, and constructors, Inheritance, encapsulation, and polymorphism, Static and dynamic objects, Use of OOP for building reusable testbench components, Randomization, Threads & Inter Process Communication.

PRACTICES:

- Structures and Unions
- Mailbox
- Interface
- Inheritance
- Polymorphism
- Randomization

MODULE-2

27L+0T+18P+27SL=72 Hours

UNIT-1: SYSTEM VERILOG TEST BENCH

Functional coverage concepts: Coverpoints, covergroups, bins, Cross coverage, coverage options, and sampling, Coverage analysis and coverage-driven verification (CDV), Writing and analyzing constrained-random testbenches, Test bench guidelines, A Complete System Verilog Test Bench (SVTB).

UNIT-2: SYSTEM VERILOG ASSERTIONS (SVA)-1

Introduction to SVA, building blocks, Properties, Boolean expressions, Sequence, Single & Multiple Clock definitions, Implication operators (Overlapping & Non- overlapping), Repetition operators.

UNIT-3: SYSTEM VERILOG ASSERTIONS (SVA)-2

Built-in System functions ($past, $stable, $onehot, $onehot0, $isunknown), Constructs (ended, and, intersect, or, first match, throughout, within, disableiff, expect, matched, if – else), Assertion directives, Nested implication, Formal arguments in property.

PRACTICES:

- Immediate and concurrent assertions
- Implication operator
- Repetition operator
- Built-in system functions
- Constructs
- Functional Verification
- Complete Test bench of adder

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Module No.	Mappingwith POs
1	Outline the System Verilog environment of digital systems.	Apply	1	1, 5, 9
2	Apply Object-Oriented Programming concepts in SystemVerilog to design modular, reusable, and efficient verification components.	Apply	1	1, 2, 5, 9

3	Model a scenario for Verification of a DUT in System Verilog.	Apply	2	1, 2, 3, 4, 5, 9, 11
4	Develop an Assertion test plan based on specifications	Analyze	2	1, 2, 3, 5, 9
5	Create System Verilog assertions using formal verification tool and analyse results	Create	2	1, 2, 3, 4, 5, 9, 11

Sustainable Development Goals (SDGs)	**Indian Knowledge System**
SDG 8 (Decent work and economic growth)	**No**
SDG 9 (Industry, Innovation, and Infrastructure)	

TEXT BOOKS:

1. Stuart Sutherland, Simon Davidmann, Peter Flake, "SystemVerilog for design: a guide to using SystemVerilog for hardware design and modeling", Springer, ISBN 1402075308, 9781402075308, 2004.
2. Stephen Prata, "C++ Primer Plus", Pearson Education Inc, 2012.

REFERENCE BOOKS:

1. Janick Bergeron, "Writing testbenches using System Verilog", Birkhäuser, 2006.
2. Ben Cohen, cohen, Venkataramanan, Kumari, Srinivasan Venkataramanan, AjeethaKumari, "SystemVerilog Assertions Handbook - for Formal and Dynamic Verification", Vhdlcohen publishing, 2005.

SKILLS:

- Write a synthesizable more efficient Verilog code and test bench for verification of complex combinational and sequential circuits.
- Analyze various FPGS archi- tectures and technologies to implement the complex designs in FPGA.



https://blogs.sw.siemens.com/verificationhorizons/2021/02/16/systemverilog-syntax/

22VLBXX - PHYSICAL DESIGN AUTOMATION

Hours per Week:

L	T	P	SL	C
3	0	2	3	4

PREREQUISITE KNOWLEDGE:

- Logic circuits
- Linear circuit analysis
- Digital system design
- VLSI
- Basic programming skills (C/C++)

COURSE DESCRIPTION AND OBJECTIVES:

This course provides an in-depth study of Physical Design Automation (PDA) techniques used in Very Large Scale Integration (VLSI) circuit design. It covers the essential stages of the backend design flow, including partitioning, floorplanning, placement, clock tree synthesis (CTS), routing, parasitic extraction, timing analysis, and power optimization.

MODULE-1

18L+0T+12P+18SL=48 Hours

UNIT-1: INTRODUCTION TO PHYSICAL DESIGN AUTOMATION

Introduction to VLSI Design flow, VLSI design cycle, new trends in VLSI design cycle,

Physical design cycle, Design styles,System packing styles- Die packing and attachment styles

UNIT-2: LAYOUT COMPACTION

Standard cell layout, Layout compaction, Design rules, symbolic layout, problem formulation, Algorithms for constraint-graph compaction.

PRACTICES:

- Using Cadence Innovus, perform Minimize the area of the design.
- Perform layout compaction while ensuring timing constraints are met.
- Optimize the layout to reduce both area and power consumption.
- After completing the layout of a simple combinational circuit (e.g., a 2-input AND gate), run Design Rule Checking (DRC) using Cadence Innovus.

MODULE-2

27L+0T+18P+27SL=72 HOURS

UNIT-1: PLACEMENT AND PARTITIONING

Design style placement problems Classification of placement algorithms, Simulation based placement algorithms and partitioning based placement algorithms. Timing-driven placement.

UNIT-2: GLOBAL ROUTING

Floor planning and routing- floor planning concepts. Shape functions and floor planning sizing. Local routing. Area routing. Channel routing, global routing and its algorithms.

UNIT-3: SIMULATION AND LOGIC SYNTHESIS

Simulation and logic synthesis- gate level and switch level modelling and simulation. Introduction to combinational logic syntheses. Introduction to High level synthesis.

PRACTICES:

- Create a clock tree for a simple design (e.g., 4-bit ALU) using Cadence Innovus

- Design a simple combinational circuit and complete the placement and routing using Cadence Innovus
- Perform post-layout power analysis in Cadence Innovus for a given design (e.g., a 16-bit register file).
- Optimize the floorplan for large designs with macro cells.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Students are able to know how to place the blocks and how to partition the blocks while for designing the layout for IC.	Understand	1,2	1, 2, 3, 4, 9, 10
2	Students are able to solve the performance issues in circuit layout.	Apply	1,2	1, 2, 3, 4, 9, 10
3	Students are able to analyze physical design problems and Employ appropriate automation algorithms for partitioning, floor planning, placement and routing	Analyze	1,2	1, 2, 3, 4, 9, 10
4	Students are able to decompose large mapping problem into pieces, including logic optimization with partitioning, placement and routing	Create	1,2	1, 2, 3, 4, 9
5.	Students are able to analyze circuits using both analytical and CAD tools	Analyze	1,2	1, 2, 3, 4, 9, 10

SDGs	IKS
SDG 4: Quality Education SDG 7 (Affordable and Clean Energy) SDG 9 (Industry, Innovation, and Infrastructure) SDG 11: Sustainable Cities and Communities SDG 12: Responsible Consumption and Production	

BOOKS AND REFERENCES

TEXT BOOK:

1. S.H. Gerez, “Algorithms for VLSI Design Automation”, John Wiley ,latest editon .

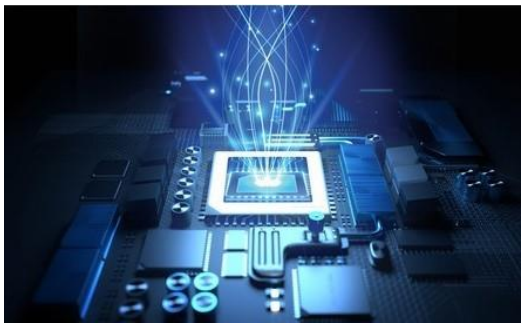
REFERENCES:

5. S.M. Sait , H. Youssef, “VLSI Physical Design Automation”, World scientific, 1999.
6. N.A.Sherwani , “Algorithms for VLSI Physical Design Automation”, (3/e), Kluwer,1999.
7.
8. M. Sarrafzadeh, “Introduction to VLSI Physical Design”, McGraw Hill (IE), 1996.
9. VLSI Physical Design Automation: Theory and Practice, Sadiq M. Sait, Wspc, 1999, ISBN 978-9810238834.
10. Algorithms for VLSI Physical Design Automation, 3/E, Naveed A. Sherwani, Springer, 1998, ISBN 978-0792383932
11. Practical Problems in VLSI Physical Design Automation, Sung Kyu Lim, Springer, 2008, ISBN 978-1402066269.

SKILLS:

- A strong understanding of the VLSI design flow is developed, covering all stages from RTL design to physical implementation.
- Proficiency in floorplanning and placement techniques is gained to optimize chip area and performance.
- Knowledge of routing algorithms and techniques is acquired to create efficient signal paths and reduce congestion.
- Skills in timing analysis and optimization are honed to ensure that designs meet clock and data path timing requirements.
- An understanding of Design for Manufacturability (DFM) is gained to ensure designs are robust for the fabrication process.
- Expertise in power analysis and optimization is developed to minimize power consumption while maintaining performance.
- Proficiency in performing physical verification and DRC/LVS checks is acquired to ensure designs meet manufacturing constraints and are error-free.

Image Source: https://www.linkedin.com/pulse/important-vlsi-blogs-learning-physical-design-sriharsha-pudi



22EEXX – RF CMOS DESIGN

Hours per week:

L	T	P	SL	C
3	0	2	3	4

PREREQUISITE KNOWLEDGE: Analog IC Design, Communication Theory, Electromagnetic Theory and Transmission Lines, Microwave Theory.

COURSE DESCRIPTION AND OBJECTIVES:

The proposed course is an advanced course towards analysis and design of RF integrated circuits and systems by systematic understanding of RF electronics. This covers topics like transceiver architectures, CMOS LNA designs, RF Mixers, RF Oscillators, Frequency Synthesizers and Power Amplifier Designs. The main objectives of the course is CMOS RF circuits analysis and designs.

MODULE-1

18L+0T+12P+18SL=48 Hours

UNIT-1: BASIC CONCEPTS IN RF DESIGN

Harmonics, gain compression, desensitization, blocking, cross modulation, intermodulation, inter symbol interference, noise figure, Friis formula, sensitivity and dynamic range.

UNIT-2: TRANSCEIVER ARCHITECTURES

Receiver: Heterodyne receivers, homodyne receivers, image-reject receivers, digital-IF receivers and subsampling receivers.

Transmitter: Direct-conversion transmitters, two-step transmitters.

PRACTICES:

- S-parameter Simulations
- Harmonic Balance Simulations
- Link Budget Analysis
- RF system Design

MODULE-2

18L+0T+12P+18SL=48 Hours

UNIT-1: CMOS LNA AND MIXER DESIGN

LNAs: General considerations, input matching, CMOS LNAs

MIXERs: General considerations, CMOS Mixers, Noise in Mixers.

UNIT-2: RF OSCILLATORS AND FREQUENCY SYNTHESIZERS

OSCILLATORS: General considerations, Basic LC Oscillator topologies, Voltage Control Oscillator, CMOS LC Oscillators.

FREQUENCY SYNTHESIZERS: General Considerations, Basic PLL, Charge-Pump PLLs, Type I and Type II PLLs, Noise in PLLs.

UNIT-3: POWER AMPLIFIERS

General Considerations, Classification of Power Amplifiers, High-Efficiency Power Amplifiers, High-Efficiency Power Amplifiers, Design Examples.

PRACTICES:

- Design of CMOS LNA.
- Design of CMOS Mixer.
- Design of CMOS Oscillator.
- Design of CMOS PA

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Mapping with POs
1.	Students can able to analysis performance metrics for RF integrated circuits	Analyze	1, 2, 4, 9, 10
2.	Students able to do analyze various transceiver architectures.	Analyze	1, 2, 9, 10
3.	They can design RF CMOS LNAs and Mixers	Apply	1, 2, 9, 10, 12
4.	Students can able to design CMOS PAs	Apply	1, 2, 9, 10, 12

Mapping of SDGs

Sustainable Development Goals (SDGs)
SDG 7 (Affordable and Clean Energy)
SDG 9 (Industry, Innovation, and Infrastructure)
SDG 11 (Sustainable Cities & Communities)
SDG 12 (Responsible Consumption and Production)

TEXT BOOKS:

5. Behzad Razavi "RF Microelectronics", 2nd Edition, Prentice Hall Communications Engineering and Emerging Technologies, 2011.

REFERENCEBOOKS:

11. Thomas H. Lee, The design of CMOS radio-frequency integrated circuit, Cambridge University Press, 2006
12. Chris Bowick, RF Circuit Design, Newnes, 2007
13. NPTEL Video Lectures

SKILLS:

- Analyzing the design challenges in RF CMOS designs
- Designing Front end amplifiers in circuit simulator tools like ADS/Cadence.
- Designing RF Mixers and Oscillators in circuit simulator tools like ADS/Cadence.

Image source: https://rfic.ece.ucsb.edu/research/radio-frequency-and-millimeter-wave-integrated-circuits.

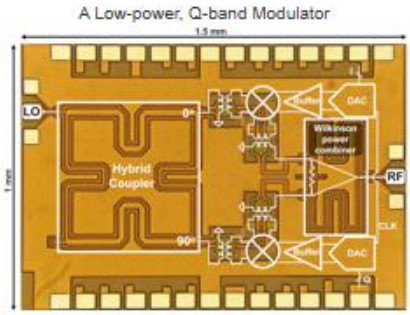


Image file name: RF CMOS DESIGN

22ECXXX – HARDWARE VERIFICATION TECHNIQUES

Hours per week:

L	T	P	SL	C
3	0	2	3	4

PREREQUISITE KNOWLEDGE: VLSI Design & Testing of VLSI Circuits

COURSE DESCRIPTION AND OBJECTIVES:

This course provides knowledge about various verification methods for software and hardware,addressing the industry needs in software/hardware co-designs. The objective of the course is to deal with the techniques for verification of hardware and concurrent software programs.

MODULE-1

18L+0T+12P+18SL=48 Hours

UNIT-1: VERIFICATION BASICS

Testbench- The importance of verification, Reconvergence model, Automation, Poka-Yoke redundancy, Equivalence checking model, Checking functional verification, Functional verification, Testing versus verification design and verification reuse.

.

UNIT-2: VERIFICATION TOOLS

Linting tools - Simulators, Verification intellectual property, Code coverage, Functional coverage verification languages, Assertions, Revision control, Issue tracking metrics, Interpreting metrics.

PRACTICES:

- Examples of Poka- Yoke redundancy
- Implementation of equivalence checking model.
- Functional verification.
- Simulation of assertions.
- Examples of Interpreting metrics

MODULE-2

27L+0T+18P+27SL=72 Hours

UNIT-1: VERIFICATION PLAN

The role of the verification plan, Levels of verification-from specification to features, directed test benches approach, Coverage driven, Random based approach directed test cases.

UNIT-2: STIMULUS AND RESPONSE

Reference signals, Simple stimulus, Simple output, Complex stimulus, Bus-functional models, Response monitors, Transaction-level interface.

UNIT-3: ARCHITECTING TEST BENCHES

Test harness, VHDL test harness, Design configuration, Self-checking test benches, directed stimulus, Random stimulus, defining scenarios, Behavioral models, Managing simulations, Regression.

.

PRACTICES:

- Examples of random based approach test cases
- Examples of Transaction-level interface
- Implementing Test harness
- Implementation of Regression

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Mapping with POs
1.	Outline the System Verilog environment of digital systems and analyze.	Understand	1, 2, 4, 5, 8, 9, 11
2.	Model a scenario for Verification of a DUT in System Verilog.	Apply	1, 2, 5, 8, 9
3.	Develop UVM environment at chip level.	Apply	1, 2, 3, 5, 8, 9
4.	Create test benches for digital systems.	Create	1, 2, 5, 8, 9, 11

Mapping of SDGs and IKS

Sustainable Development Goals (SDGs)	Indian Knowledge System
SDG 8 (Decent Work and Economic Growth)	**No**
SDG 9 (Industry, Innovation, and Infrastructure)	

TEXT BOOKS:

1. Stuart Sutherland, Simon Davidmann, Peter Flake, "System Verilog for design: a guide to using System Verilog for hardware design and modeling", Springer, ISBN 1402075308, 9781402075308, 2004
2. Stephen Prata, "C++ Primer Plus", Pearson Education Inc, 2012.
3. William K. Lam, "Hardware Design Verification: Simulation and Formal Method-Based Approaches", Pearson, ISBN: 9780131433472, 2005.

REFERENCEBOOKS:

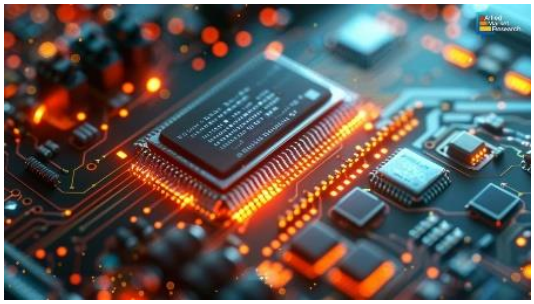
14. Chris Spear, "System Verilog for Verification: A Guide to Learning the Test bench Language Features", 2nd edition, Published by Springer, 2008.
15. Srikanth Vijayaraghavan, Meyyappan Ramanathan, "A Practical guide for System Verilog Assertions", Springer, 2005.
16. Sharon Rosenberg, Kathleen A Meade, "A practical guide to adopting the Universal Verification Methodology", 2010.

SKILLS:

- Verify the functional properties of the hardware design.
- Write test benches for functional verification of HDL models.
- Realize impact of HVT on modern designs.

Image source: https://media.licdn.com/dms/image/D4D12AQFaweiu0IzA_A/article-cover_image-shrink_720_1280/0/1711020399440?e=1723680000&v=beta&t=S-uZR7VDgJpk6gvhjseTlxwHq_4PnnBTS2ipfFFkBek.

Image file name:



22XXXXX – Mixed Signal Design

Hours per week:

L	T	P	SL	C
3	0	2	3	4

PREREQUISITE KNOWLEDGE: CMOS Analog IC design.

COURSE DESCRIPTION AND OBJECTIVES:

This course focuses on advanced design approaches for bandgap references, comparators, ADC/DAC, oscillators, and PLL. The objective of the course is to build and implement the product level design blocks for VLSI applications.

MODULE-1

18L+0T+12P+18SL=48 Hours

UNIT-1: Mixed signal circuits

Comparator & Multiplier: Characterization of a comparator, Basic CMOS comparator design, analog multiplier

PLL: Simple PLL, charge-pump PLL, applications of PLL

UNIT-2: Switched Capacitor and sample and hold circuits

Switched Capacitor circuits: Basic principles, switched capacitor sensitive integrator and insensitive integrator, switched capacitor filter, switched capacitor amplifier.

Sample & hold and trans-linear circuits: Performance of sample-and-hold circuits, MOS sample-and-hold basics, examples of CMOS S/H Circuits, trans-linear gain Cell, trans-linear multiplier.

PRACTICES:

Design and simulate the following mixed signal circuits.

- High speed and high gain comparators.
- PLL
- Switched Capacitor circuits.
- Sample and Hold circuit.

MODULE-2

27L+0T+18P+27SL=72 Hours

UNIT-1: Analog Filters

Analog CMOS Filters: Low Pass filters, active–RC fully differential integrator, Two transistor MOSFET– C integrator, gm-C Integrator, Active RC integrators.

UNIT-2: Digital to Analog Converters

Data converters specifications: Ideal D/A converter, quantization noise, performance metrics, resolution, offset and gain error, accuracy, and linearity.
D/A Converter architectures: Resistor-Ladder architectures, Capacitive DAC, Cyclic DAC, current-steering, Pipeline DAC.

UNIT-3: Analog to Digital Converters

ADC Specifications, ideal A/D converter, A/D converter architectures: Flash architectures, interpolate and folding architectures, pipelined architectures, Ramp type ADC, Integrating (Dual slope) ADC, Successive approximation architectures, Sigma Delta ADC, Design of Decimation filter.

PRACTICES:

Design and simulate the following mixed signal circuits.

- First order filter

- gm-C Integrator
- Capacitive DAC
- Flash ADC

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Analyze CMOS based comparator and PLL.	Understand	1	1, 2, 5, 9, 11
2	Use the techniques and skills for designing CMOS based switched capacitor circuits and enhance the performance of sampling circuits	Apply	1	1, 2, 3, 5, 9
3	Design the frequency and Q tunable time domain filters	Apply	2	1, 2, 3, 5, 9, 11
4	Identify, formulates, and solves engineering problems in data converters of mixed-signal design	Analyze	2	1, 2, 3, 4, 5, 9, 11

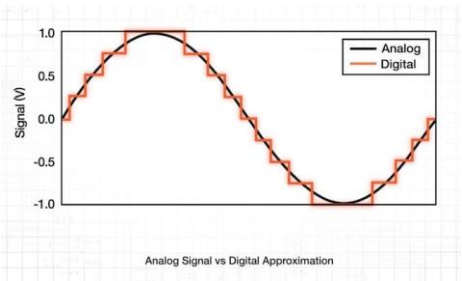
Sustainable Development Goals (SDGs)	Indian Knowledge System
SDG 8 (Decent work and economic growth)	**No**
SDG 9 (Industry, Innovation, and Infrastructure)	

TEXT BOOKS:

1. B.Razavi, "Design of analog CMOS integrated circuits", McGraw Hill, 2001.
2. B.Razavi, "Principles of data conversion system design", S.Chand and company ltd, 2000.
3. Jacob Baker et. all, "CMOS Mixed-Signal circuit design", IEEE Press, 2002

REFERENCE BOOKS:

1. Gregorian, Temes, "Analog MOS Integrated Circuit for signal processing", John Wiley & Sons.
2. Schreier & Themes, Understanding Delta-Sigma Data Converters, Wiley –IEEE Press, 2004.



https://www.allaboutcircuits.com/uploads/articles/ADC_and_DAC_mixed_signal_ICs.jpg

SKILLS:

- Identify and analyse various switched capacitor circuits.
- Design of phase locked loops.
- Analyse the performance of ADC's & DAC's.

22XXXXX – Hardware Security

Hours per week:

L	T	P	SL	C
3	0	2	3	4

PREREQUISITE KNOWLEDGE: Algebra of Finite Fields, Basics of the Mathematical Theory of Public Key Cryptography, Basics of Digital Design on Field-programmable Gate Array (FPGA), Classification using Support Vector Machines (SVMs) .

COURSE DESCRIPTION AND OBJECTIVES:

This course covers hardware security threats, countermeasures, and cryptographic techniques in VLSI circuits and embedded systems**.** It focuses on secure chip design, side-channel attacks, physical security, and AI-driven security mechanisms in modern semiconductor technologies.

MODULE-1

18L+0T+12P+18SL=48 Hours

UNIT-1: Introduction to Hardware Security

Overview of Hardware Security in VLSI & Embedded Systems, Types of Security Threats: Physical attacks, Side-channel attacks, Hardware Trojans, Comparison of Hardware and Software Security Mechanisms, Trusted Computing and Secure Boot

UNIT-2: Cryptographic Hardware & Secure Key Management

Introduction to Cryptographic Primitives (AES, RSA, ECC), Implementation of Cryptographic Algorithms, True Random Number Generators (TRNGs) and Physically Unclonable Functions (PUFs), Key Management and Secure Key Storage in Hardware, Secure Hardware for Block-chain and IoT Devices

PRACTICES:

1. Side-Channel Attack Demonstration on Cryptographic Circuits
2. Implementation of PUFs for Chip Authentication

MODULE-2

27L+0T+18P+27SL=72 Hours

UNIT-1: Side-Channel Attacks and Countermeasures

Types of Side-Channel Attacks: Power Analysis, Timing Analysis, Fault Injection Attacks (Laser, EM, Voltage, Clock Glitches), Countermeasures: Masking, Obfuscation, Shielding, Error Correction

UNIT-2: Hardware Trojans & Backdoors in ICs

Hardware Trojans (HTs) and Their Types, HT Detection Techniques: Functional testing, Side-channel analysis, Machine Learning.

UNIT-3: Secure System-on-Chip (SoC) and FPGA Security

Secure SoC Architectures: Secure Boot, Trusted Execution Environment (TEE), FPGA Security Threats: Bit stream Attacks, Reverse Engineering, FPGA-based Cryptographic Acceleration, AI-Driven Threat Detection in FPGA and ASIC Designs, AI-based Side-Channel Attack Mitigation

PRACTICES:

1. Design and Testing of Secure Boot Mechanisms
2. Simulation of Hardware Trojan Insertion and Detection

3. FPGA-based Cryptographic Acceleration using AES/RSA

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Module No.	Mappingwith POs
1	Explain fundamental concepts of hardware security, including security threats, trusted computing, and secure boot mechanisms.	Apply	1	1,2
2	Analyze cryptographic hardware implementations, including AES, RSA, ECC, TRNGs, and PUFs, and their applications in blockchain and IoT security.	Apply	1	1,2,5
3	Demonstrate practical knowledge of side-channel attacks and evaluate countermeasures such as masking, obfuscation, and shielding.	Apply	2	2,4,5
4	Identify and assess different types of hardware Trojans and backdoors, and implement detection techniques using functional testing and machine learning.	Analyze	2	2,4,6
5	Develop secure System-on-Chip (SoC) architectures, analyze FPGA security threats, and implement cryptographic acceleration techniques.	Create	2	3,5,6

Sustainable Development Goals (SDGs)	Indian Knowledge System
SDG 9 (Industry, Innovation, and Infrastructure)	**No**
SDG 16 (Peace, Justice, and Strong Institutions)	
SDG 11 (Sustainable Cities and Communities)	

TEXT BOOKS:

1. Hardware Security: A Hands-on Learning Approach" – Patrick Schaumont
2. "Introduction to Hardware Security and Trust" – Mohammad Tehranipoor, Cliff Wang

REFERENCE BOOKS:

3. Secure Integrated Circuits and Systems" – Ingrid Verbauwhede
4. IEEE Transactions on Hardware Security & Trust



https://www.google.com/search?sca_esv=48b159fac8a0db64&q=picture+define+hardware+security&udm=2&fbs=ABzOT_CWdhQLP1FcmU5B0fn3xuWpA-dk4wpBWOGsoR7DG5zJBtmuEdhfywyzhendkLDnhcrUz6wxBwARHD96EKWkSbZoqXb6uOuzhtkIDhbKMFBTOSopnMSiYQfajMRcOqHpFXj3MvNgaPQFjYSth_B7PeWZd4wmd9iTUyue1WTPC-jJ1U1mlShH2ahP0mdATp_30wSS_jN6b36eWt-HeCNcXieHMaQ2FQ&sa=X&ved=2ahUKEwi01oSN9KmMAxXoSGcHHeseC5UQtKgLegQIFBAB&biw=1366&bih=641&dpr=1#imgrc=OtJnv_SoFFS8kM&imgdii=H48djaTQFAez1M

SYSTEM ON CHIP DESIGN

Hours per week:

L	T	P	SL	C
3	2	0	3	4

PREREQUISITE KNOWLEDGE: VLSI Design, Digital Design.

COURSE DESCRIPTION AND OBJECTIVES: This course offers the concepts of integrating all components of any electronic system into a single chip. The objective of the course is to introduce the students to digital, analogue, mixed- signal, and radio-frequency functions to integrate all on a single chip substrate.

MODULE-1

18L+12T+0P+18SL=48 Hours

UNIT-1: INTRODUCTION TO SoC TECHNOLOGY

System trade-offs and evolution of ASIC technology, System on chip concepts and Methodology and design paradigms in SoC development.

UNIT-2: CORE SoC DESIGN CHALLENGES AND COMPONENTS

SoC Design Issues: Complexity management, Power management and thermal considerations, Signal integrity and noise analysis, Clock distribution and synchronization, Verification and testing.
SoC Components: Processor cores, Memory subsystems, Peripheral interfaces (I/O), Interconnect architectures (buses, NoC).

PRACTICES:

- Compare ASIC and SoC implementations by studying their evolution
- Analyze complex SoC flows to then outline a top-down design process using studied methodologies.
- Analyze CPU power consumption characteristics to formulate a power management strategy for a wearable System-on-Chip.
- Explore on-chip interconnect architectures and analyze their suitability for different SoC types
- Examine clock distribution challenges and signal integrity issues in high-speed I/O

MODULE-2

27L+18T+0P+27SL=72Hours

UNIT-1: LOGIC CORE DESIGN METHODOLOGY

SoC Design Flow, Specification, design, implementation, and verification stages, Hardware Description Languages (HDLs), Synthesis and place-and-route, On-Chip Buses, Logic Core Types and Design, Hard cores, soft cores, and firm cores: characteristics and design processes

UNIT-2: MEMORY and ANALOG CORE DESIGN

Embedded Memories, Types of embedded memories, Memory design considerations (area, speed, power), Analog Core Design, Simulation and specification of analog circuits, ADCs, PLL, High-speed I/O design.

UNIT-3: SoC VALIDATION and TESTING

Functional verification of individual cores, Hardware/software co-simulation and co-verification, System-level testing and validation, **SoC Test Issues and Techniques:** Testing of digital logic cores, Built-in self-test (BIST) methods, Case studies on SoC validation and testing.

PRACTICES:

- Analyze test bench simulations to verify logic core functionality against specifications.
- Examine core type choices (hard, soft, firm) relative to SoC specifications and design workflow.
- Study memory types and ADC principles to learn embedded and analog core design.
- Apply HDL design to synthesize a logic core; apply BIST to simulate fault coverage.
- Develop a cost-benefit analysis for SoC testing from a case study, examining equipment, time, and yield gains.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1.	Analyze the fundamental concepts, methodologies, design issues of System- on-Chip.	Analyze	1	1, 2, 4, 5, 8, 9, 11

2.	Identify and describe the key components of an SoC, such as processor cores, memory subsystems, and interconnect architectures.	Apply	1	1, 2, 5, 8, 9
3.	Apply the knowledge of methods and design issues in hard-core, soft-core process and analogue circuits.	Apply	2	1, 2, 3, 5, 9, 10
4.	Analyze the software and hardware simulation and validate it.	Analyze	2	1, 2, 5, 9, 10, 12
5.	Articulate the complexities of ensuring testability for digital logic cores.	Apply	2	1, 2, 5, 9, 10

Mapping of SDGs and IKS

Sustainable Development Goals (SDGs)	**Indian Knowledge System**
SDG 9 (Industry, Innovation, and Infrastructure)	YES

TEXT BOOKS:

1. Rochit Rajsuman, "System-on-a-chip: Design and Test", 2nd edition, Santa Clara, CA: Artech House, 2000.
2. Prakash Rashinkar, Peter Paterson and Leena Singh, "System-on-a-chip verification: Methodology and Techniques", 3rd edition, Kluwer Academic Publishers, 2011.

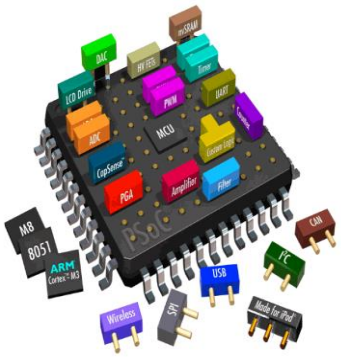
REFERENCE BOOKS:

1. M. Keating, D.Flynn, R.Aitken, A. Gibbons and K. Shi, "Low Power Methodology Manual for System-On-Chip Design Series (Integrated Circuits and Systems)", 2nd edition, Springer, 2007.
2. L.Balado and E. Lupon, "Validation and test of systems on chip", Twelth Annual IEEE conference on ASIC/SOC, 1999.

SKILLS:

- Analyze SoC trade-offs for optimization.
- Use HDL to design logic cores.
- Design on-chip bus/NoC architectures.
- Select embedded memory for applications.
- Simulate and analyze analog circuits.
- Verify SoC using test benches.
- Co-simulate hardware and software designs.
- Manage complete SoC design flow.

Image



:

Image source: https://microcontrollerslab.com/system-on-chip-soc-introduction/

QUANTUM COMPUTING IN VLSI

Hours per Week:

L	T	P	SL	C
2	2	0	2	3

PREREQUISITE KNOWLEDGE:

- Linear Algebra
- Basic Quantum Mechanics
- Computational Theory
- Classical Programming (e.g., Python, C++, Java)
- Digital Logic Design
- VLSI Design Fundamentals
- CMOS Technology and Semiconductor Physics

COURSE DESCRIPTION AND OBJECTIVES:

This course provides an in-depth exploration of the intersection between quantum computing and VLSI design. It introduces students to the principles of quantum mechanics and quantum computing, along with the application of these concepts to the design and implementation of quantum circuits within VLSI systems. The course covers quantum algorithms, quantum error correction, quantum hardware, and how quantum systems are integrated with classical VLSI components

MODULE-1

12L+12T+0P+12SL=36 Hours

UNIT-I: INTRODUCTION TO QUANTUM COMPUTING

Basic of quantum mechanics, quantum postulates, superposition, entanglement and, No cloning theorem

UNIT-2: QUBIT AND ITS STATES

Qubits, measurement on single and multiple qubits, Hilbert space, state vector Bra-Ket notation, Bloch sphere, Protocols with multi-qubits: Swapping - Teleportation - gates: CNOT - Toffoli gate - NAND - FANOUT - Walsh Hadamard

MODULE-2

18L+18T+0P+18SL=54 Hours

UNIT-I: QUANTUM COMPUTING AND NETWORK COMPONENTS

Single and two Qubit quantum gates, unitary transformation, composite state tensor Product, cascade and parallel quantum circuits, Quantum diode, quantum router, quantum memory.

UNIT-II: POTENTIAL QUANTUM ALGORITHMS

Classical computing using qubits - Quantum key distributions, quantum teleportation, Grovers algorithm (data base search) and shor's algorithm, Deutsch-Jozsa algorithm.

UNIT-III: QUANTUM CIRCUITS

Basic gates - ABC decomposition - Gray codes - Universal gates - Principle of deferred and implicit measurements - Quantum Fourier transform - applications: phase estimation, order finding - factoring, discrete logarithm and hidden subgroup problems. Quantum error correcting codes, Physical realization of qubits.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Understand the principles of quantum computation qubit	Apply	1,2	2, 3, 4, 9, 10
2	Analyze multi-qubit systems and protocols	Create	1,2	2, 3, 4, 9, 10
3	Apply quantum measurement and entanglement concepts	Create	1,2	2, 3, 4, 9, 10
4	Design and implement quantum algorithms and circuits	Create	1,2	2, 3, 4, 9, 10

SDGs	IKS
SDG 7 (Affordable and Clean Energy) SDG 9 (Industry, Innovation, and Infrastructure) SDG 12(Responsible Consumption and Production)	

BOOKS AND REFERENCES

TEXT BOOK:

1. M. A. Nielsen and I. L. Chuang, Quantum Computation and Quantum Information, Cambridge University Press, 2010, 10th Anniversary Edition

REFERENCES:

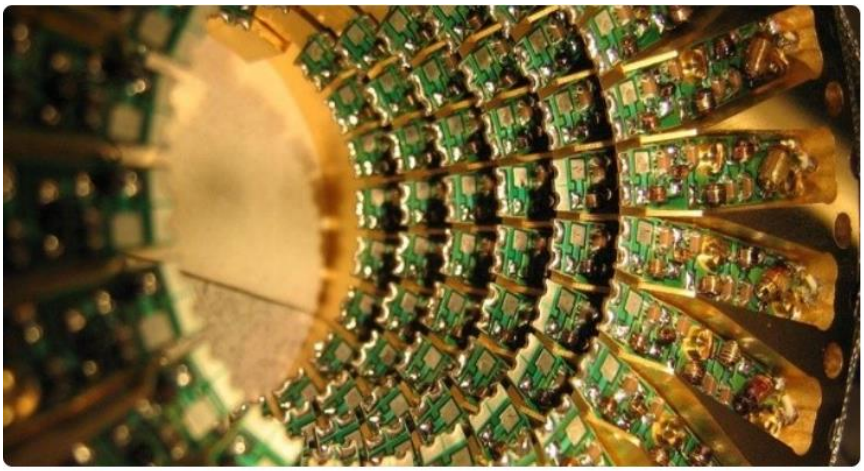
1. Quantum Theory: Concepts and Methods, Asher Peres, Kluwer Academic Publishers, 1993.
2. Venkateswaran Kasirajan, Fundamentals of Quantum Computing: Theory and Practice, Springer, 2021.
3. Chris Bernhardt, Quantum Computing for Everyone, The MIT Press, 2019.

SKILLS:

- A deep understanding of quantum mechanics and quantum computing principles is developed, covering concepts like superposition, entanglement, qubits, and quantum gates.

- Proficiency in quantum algorithm design is gained, including key algorithms like Shor's for factoring and Grover's for searching, and their applications to real-world problems.
- A strong understanding of quantum circuit design is developed, covering the creation and optimization of quantum gates and quantum circuits.
- Experience in hybrid quantum-classical systems integration is gained, with a focus on how classical VLSI components control quantum processors and ensure efficient communication.
- Knowledge of quantum error correction (QECC) and fault-tolerant quantum computing is acquired, with the ability to implement and troubleshoot error correction techniques in quantum circuits.
- Experience in simulating and testing quantum circuits is gained, using tools like Qiskit, and ensuring quantum circuits meet performance metrics such as fidelity, coherence time, and gate error rates.

Image Source:
https://www.google.com/search?q=quantum+mechanics+QUANTUM+COMPUTING+IN+VLSI&sca_esv=ee3395f8cbb9de9c&rlz=1C1CHZN_enIN1146IN1146&udm=2&biw=1366&bih=641&sxsrf=AHTn8zp5DbT1hk5DJK6SRYCNySK7anp5JA%3A1741854953150&ei=6ZjSZ6TmCNGt4-EPn5fzmAc&ved=0ahUKEwjk_u2t04aMAxXR1jgGHZ_LHHMQ4dUDCBI&oq=quantum+mechanics+QUANTUM+COMPUTING+IN+VLSI&gs_lp=EgNpbWciK3F1YW50dW0gbWVjaGFuaWNzIFFVQU5UVU0gQ09NUFVUSU5HIElOIFZMU0lIww5QAFgAcAF4AJABAJgBAKABAKoBALgBDMgBAJgCAKACAJgDAIgGAZIHAKAHAA&sclient=img#vhid=0h5OfELgBMjbSM&vssid=mosaic.



22ECXXXX – PHOTONICS AND OPTICAL CIRCUITS

L	T	P	SL	C

3	2	0	3	4

PREREQUISITE KNOWLEDGE: Basic understanding of VLSI Design**,** Fundamentals of Electromagnetic Theory**,** Semiconductor Physics.

COURSE DESCRIPTION AND OBJECTIVES:

This course introduces the principles of photonics and optical circuits, focusing on their integration with VLSI technology. Students will learn about light-matter interaction, optical materials, waveguides, photonic devices and their applications in communication, sensing and computing. The course also covers emerging trends in photonic integrated circuits (PICs) and their role in next-generation VLSI systems.

MODULE-1

UNIT-1: INTRODUCTION TO PHOTONICS AND OPTICAL MATERIALS

[8L+8T+0P=16 Hours]

Introduction to Photonics: Historical perspective, importance in modern technology. Light Matter Interaction: Absorption, emission, and scattering of light. Optical Materials: Dielectric materials, semiconductors and polymers for photonics. Optical Properties of Materials: Refractive index, dispersion and nonlinear optical effects. Emerging Materials: Photonic crystals, metamaterials, and 2D materials.

UNIT-2: OPTICAL WAVEGUIDES AND FIBERS

[8L+8T+0P=16 Hours]

Waveguide Fundamentals: Modes, dispersion and confinement of light. Types of Waveguides: Planar waveguides, channel waveguides and photonic crystal waveguides. Optical Fibers: Structure, modes, and propagation characteristics. Fiber Optic Communication: Principles, advantages and challenges. Applications of Waveguides and Fibers: Optical interconnects, sensors, and integrated photonics.

MODULE-2

UNIT-1: PHOTONIC DEVICES AND COMPONENTS

[6L+6T+0P=12 Hours]

Light Sources: LEDs, laser diodes and vertical-cavity surface-emitting lasers (VCSELs). Photodetectors: PIN photodiodes, avalanche photodiodes and phototransistors. Modulators and Switches: Electro-optic, thermo-optic and acousto-optic devices. Passive Components: Couplers, splitters and filters. Emerging Devices: Plasmonic devices, quantum dot-based devices and integrated photonic circuits.

UNIT-2: PHOTONIC INTEGRATED CIRCUITS (PICs)

[6L+6T+0P=12 Hours]

Introduction to PICs: Design principles and fabrication techniques. Integration with VLSI: Challenges and opportunities. Materials for PICs: Silicon photonics, III-V semiconductors, and hybrid integration. Applications for PICs: Optical communication, data centers and quantum computing.

UNIT-3: APPLICATIONS AND EMERGING TRENDS IN PHOTONICS

[6L+6T+0P=12 Hours]

Optical Communication Systems: Wavelength division multiplexing (WDM), coherent communication, and free-space optics. Optical Sensors: Fiber Bragg gratings, surface plasmon resonance (SPR) sensors and biosensors. Photonics in Computing: Optical interconnects, photonic neural networks and quantum photonics. Emerging Trends: Integrated quantum

photonics, topological photonics and AI-driven photonic design. Sustainability in Photonics: Energy-efficient photonic devices and green manufacturing.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Bloom's Level	Module No.	Mapping with POs
1	Understand the principles of light-matter interaction and optical materials.	Understand	1	1, 2, 3, 4, 5
2	Analyze and design optical waveguides and fibers for specific applications.	Analyze	1	1, 2, 3, 4, 5
3	Evaluate the performance of photonic devices and components.	Evaluate	2	1, 2, 3, 4, 5
4	Design and simulate photonic integrated circuits (PICs) for VLSI applications.	Create	2	1, 2, 3, 4, 5
5	Explore emerging trends and applications of photonics in communication, sensing, and computing.	Apply	2	1, 2, 3, 4, 5

SDGs	IKS
SDG 7 (Affordable and Clean Energy)	Ancient Indian Optics (Surya Siddhanta, Aryabhata, Varahamihira) – Concepts of light propagation and refraction, relevant to solar energy harvesting using photonic materials.
SDG 9 (Industry, Innovation, and Infrastructure)	Temple Optics and Precision Engineering – High-precision optical alignments in ancient temples (Konark Sun Temple) inspiring modern optical circuit alignment techniques.
SDG 12 (Responsible Consumption and Production)	Advanced Material Knowledge – Use of natural dyes and materials for optical coatings in ancient Indian art, relevant to eco-friendly photonic device fabrication.
SDG 11 (Sustainable Cities and Communities)	Jantar Mantar (Astronomical Observatories) – Precision optical instruments used for celestial navigation, influencing modern LIDAR and optical sensing technologies.

TEXT BOOKS:

1. Bahaa E. A. Saleh and Malvin Carl Teich, *Fundamentals of Photonics*, 3rd Edition, Wiley, 2019.
2. Richard S. Quimby, *Photonics and Lasers: An Introduction*, Wiley, 2006.

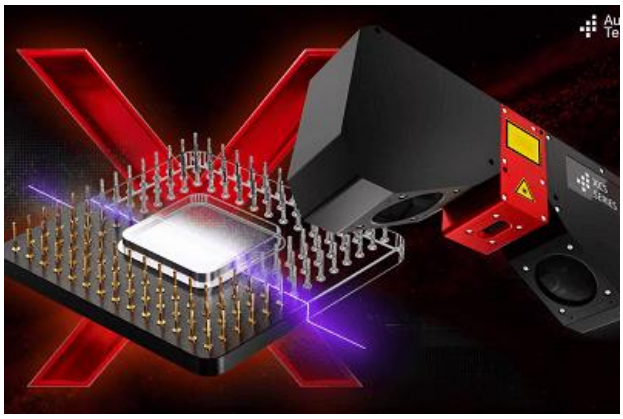
REFERENCE BOOKS:

1. Lionel C. Kimerling et al., *Silicon Photonics: The State of the Art*, Wiley, 2008.
2. Gerd Keiser, *Optical Fiber Communications*, 5th Edition, McGraw-Hill, 2015.
3. John M. Senior, *Optical Fiber Communications: Principles and Practice*, 3rd Edition, Pearson, 2009.
4. David A. B. Miller, *Quantum Mechanics for Scientists and Engineers*, Cambridge University Press, 2008.

SKILLS:

- Gain a deep understanding of photonic principles and their integration with VLSI technology.
- Learn to design and analyze optical waveguides, fibers and photonic devices.
- Develop skills in simulating and optimizing photonic integrated circuits (PICs).
- Explore emerging trends and applications in photonics for communication, sensing, and computing.

Image Link : https://www.photonics.com/Issues/Photonicscom_May_2024/i1830



22XXXXX – AI-VLSI

Hours per week:

L	T	P	SL	C
3	0	2	3	4

PREREQUISITE KNOWLEDGE: Linear Algebra, Fundamentals of VLSI Design and Image Processing

.

COURSE DESCRIPTION AND OBJECTIVES:

Artificial Intelligence (AI) is revolutionizing VLSI (Very Large Scale Integration) by enhancing chip design, verification, optimization, and manufacturing**.** AI-driven tools are helping reduce design complexity, improve power efficiency, and accelerate time-to-market for semiconductor devices. AI in VLSI course is designed to introduce students to the integration of Artificial Intelligence (AI) and Machine Learning (ML) techniques in Very Large Scale Integration (VLSI) design, verification, and manufacturing**.** The scope of AI/ML at various levels of abstraction will be covered in detail.

MODULE-1

18L+0T+12P+18SL=48 Hours

UNIT1: Introduction to VLSI and AI:
Basics of VLSI Design**,** Evolution of AI in VLSI, Supervised, Unsupervised, and Reinforcement Learning, Role of AI in modern semiconductor industry

Unit 2: AI in VLSI Design Automation (EDA Tools):
AI-enhanced Electronic Design Automation (EDA), Logic synthesis & AI-based RTL (Register Transfer Level) optimization, Placement and Routing using AI, AI-assisted power, performance, and area (PPA) optimization, Reinforcement Learning for floor-planning and chip layout optimization

PRACTICES:

1. AI-based logic synthesis using Cadence/Synopsys tools
2. ML models for power and performance estimation

MODULE-2

27L+0T+18P+27SL=72 Hours

Module II
Unit 1: AI for Verification & Testing in VLSI
AI-driven Functional Verification, Machine Learning for Design for Testability (DFT) and test pattern generation.

Unit 2: AI in Semiconductor Manufacturing & Yield Prediction:
AI-based defect detection in semiconductor wafers, Computer Vision for wafer inspection and process monitoring, Yield prediction

Unit 3: AI in FPGA & ASIC Design:
Neural network accelerators in FPGA, AI-optimized ASIC design for deep learning applications, Reconfigurable AI architectures for low-power and edge computing

PRACTICES:

1. AI-driven fault analysis for VLSI circuits

2. Computer Vision for wafer defect detection
3. Implementation of AI-optimized FPGA accelerators

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Module No.	Mappingwith POs
1	Abe to get fundamentals of VLSI design and the role of AI in semiconductor technology.	Understand	1	1,2
2	Analyze the application of AI in Electronic Design Automation (EDA) tools for logic synthesis, placement, routing, and PPA optimization.	Analyze	1	1,2,5
3	Apply AI techniques in functional verification, testing, and Design for Testability (DFT) for VLSI circuits.	Apply	2	2,4,5
4	Evaluate AI-driven approaches for defect detection, wafer inspection, and semiconductor yield prediction using machine learning and computer vision.	Evaluate	2	2,4,6
5	Design AI-optimized FPGA and ASIC architectures for deep learning, edge computing, and low-power applications.	Create	2	3,5,6

Sustainable Development Goals (SDGs)	Indian Knowledge System
SDG 7 (Affordable and Clean Energy)	**No**
SDG 8 (Decent work and economic growth)	
SDG 9 (Industry, Innovation, and Infrastructure)	
SDG 12 (Responsible Consumption and Production)	

TEXT BOOKS:

1. AI in Semiconductor Manufacturing and Design – Springer
2. VLSI Design Methodologies and AI – IEEE Transactions

REFERENCE BOOKS:

1. Machine Learning Applications in VLSI – Elsevier
2. Research Papers from IEEE, ACM
3. .**Andrew B. Kahng** – Research on AI-driven VLSI design methodologies.
4. **Swarup Bhunia & Mark Tehranipoor** – AI in hardware security and VLSI testing.
5. **Kaushik Roy** – Machine learning applications in VLSI circuits.
6. **Giovanni De Micheli** – AI-enhanced CAD tools for semiconductor design

Image



https://www.google.com/search?q=AI+in+VLSI+design+image&oq=AI+in+VLSI+design+image&gs_lcrp=EgZjaHJvbWUyBggAEEUYOTIHCAEQIRigATIHCAIQIRigATIHCAMQIRifBTIHCAQQIRifBdIBCDU5NDBqMGo3qAIAsAIA&sourceid=chrome&ie=UTF-8#vhid=sx3T95vJXMSm5M&vssid=_f7vkZ8ekDaSZseMP097NsAU_44

IoT Architecture

Hours per week:

L	T	P	SL	C
2	2	2	2	4

PREREQUISITE KNOWLEDGE: CN

COURSE DESCRIPTION AND OBJECTIVES:

This course introduces the Architecture of IoT, basic concepts of IoT architectures and IoT Levels. The Course emphasizes the constraints, requirements, and architectures of hardware and software components for IoT systems. By the end of the course, a student will be able to develop IoT solutions based on popular hardware/software platforms to address real-life problems and evaluate the cost, power, and performance trade-offs associated with IoT solution.

MODULE-1

12L+12T+12P+12SL=48 Hours

UNIT-1: INTRODUCTION

Introduction: Applications, Characteristics of IoT, Physical Design of IoT, Logical Design of IoT.

UNIT-2: IoT PHYSICAL DEVICES AND END POINTS

IoT Levels, Arduino, ESP8266, Exemplary Device- Raspberry Pi, Interfaces and Other IoT devices.

PRACTICES:

.

- Familiarization with Arduino boards and ESP8266.
- Interfacing of LED and switch with Arduino boards and ESP8266.
- Traffic Light control using Arduino board and ESP8266.
- Interfacing DHT11 sensor with Arduino board and ESP8266.
- Interfacing of ultrasonic sensor with Arduino board and ESP8266.

MODULE-2

18L+18T+18P+18SL=72 Hours

UNIT-1: INTERNET PRINCIPLES & M2M

Internet Principles: Internet communications: IP addresses, MAC addresses, TCP and UDP ports, Application layer protocols; Python packages of interest for IoT.

M2M: Introduction to M2M, M2M architecture, Difference between IoT and M2M, SDN and NFV for IoT. The IoT Architectural Reference Model as Enabler,

UNIT-2: IOT ARCHITECTURE AND PROTOCOLS

IoT Reference Architecture: Architecture, Functional, information, deployment and operation views; SOA based Architecture, API-based Architecture, OPEN IoT Architecture for IoT/Cloud Convergence. Application Protocols for IoT: UPnP, CoAP, MQTT, XMPP. SCADA, WebSocket; IP-based protocols: 6LoWPAN, RPL; Authentication Protocols; IEEE 802.15.4.

UNIT-3 IOT REFERENCE ARCHITECTURE

IIoT Architecture: The IIC Internet Reference Architecture, Industrial Internet Architecture Framework (IIAF), Architectural Topology, The Three-Tier Topology, Connectivity, Key System Characteristics, Data Management.

DESIGNING INDUSTRIAL INTERNET SYSTEMS: The Concept of the IIoT, The Proximity Network, WSN Edge Node, Legacy Industrial Protocols, Modern Communication Protocols, Wireless Communication Technologies, Proximity Network Communication Protocols.

PRACTICES:

- Familiarization of Arduino with MQTT.
- Interfacing of LED and switch with Raspberry pi.
- Interfacing PIR, Ultrasonic sensor with ESP8266 and cloud.
- To interface Bluetooth with Arduino/Raspberry Pi and write a program to send sensor data to the smartphone using Bluetooth.
- To interface node MCU with Arduino/Raspberry Pi and write a program to send sensor data to the smartphone using Blynk Application/Cloud.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Mapping with POs
1.	Understand the fundamental concepts, characteristics, and enabling technologies of IoT.	Understand	1, 2, 3
2.	Build the IoT Design with sensors and actuators and analyse the levels of Arduino programming language.	Apply	1, 2, 5
3.	Analyze Internet principles, communication protocols, and M2M concepts for IoT networking.	Analyze	1, 2, 3, 5, 11
4.	Make use of sensors for collection data from the physical medium.	Apply	1, 2, 3, 5, 8, 11
5.	Evaluate cloud platforms, virtualization, and IoT data management techniques.	Evaluate	1, 2, 3, 5, 8, 9 11
6.	Develop IoT applications.	Apply	1, 2, 3, 5, 7, 8, 9, 11

SDG MAPPING

(Course Contents Related SDGs Description)

Unit/Topic	SDG	Connection to SDG
Definition and Characteristics of IoT	SDG 9: Industry, Innovation, and Infrastructure	Promotes innovation in industry through IoT applications.
Sensors and Actuators	SDG 11: Sustainable Cities and Communities	Enables smart, sustainable urban solutions.
IoT Physical Design	SDG 12: Responsible Consumption and Production	Facilitates efficient and sustainable resource utilization.
IoT Logical Design	SDG 9: Industry, Innovation, and Infrastructure	Advances technological infrastructure.
IoT Enabling Technologies	SDG 4: Quality Education	Encourages education in modern technologies.
IoT Levels and Devices	SDG 9: Industry, Innovation, and Infrastructure	Enhances the integration of IoT devices for better efficiency.
Internet Principles	SDG 17: Partnerships for the Goals	Supports connectivity and collaboration across platforms.
M2M, IIAF and IIC	SDG 9: Industry, Innovation, and Infrastructure	Bridges technology for sustainable development.

TEXT BOOKS:

1. Vijay Madisetti, Arshdeep Bahga, “Internet of Things A Hands-On- Approach”, 2014..

2. Giacomo Veneri; Antonio Capasso, “Hands-on Industrial Internet of Things : create a powerful Industrial IoT infrastructure using Industry 4.0”, ,Packt Publishing, 2018

REFERENCEBOOKS:

1. M. Olivier Hersent, David Boswarthick, Omar Elloumi – The Internet of Things: Key Applications and Protocols, Wiley, 2nd Edition, 2021..
2. Pethuru Raj, Anupama C. Raman – The Internet of Things: Enabling Technologies, Platforms, and Use Cases, CRC Press, 2017.
3. Brett McLaughlin – Making Sense of IoT: Connecting the Digital and Physical Worlds, O'Reilly Media, 2021.
4. Bassi, Alessandro, et al, “Enabling things to talk”, Springer-Verlag Berlin An, 2016.
5. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, “IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things”, CISCO Press, 2017
6. Hersent, Olivier, David Boswarthick, and Omar Elloumi. The internet of things: Key applications and protocols. John Wiley & Sons, 2011.
7. Buyya, Rajkumar, and Amir Vahid Dastjerdi, eds. Internet of Things: Principles and paradigms. Elsevier, 2016
8. Alasdair Gilchrist,“Industry 4.0: The Industrial Internet of Things” by, ISBN: 978-1-4842-2046-7, APRESS, 2016.

9. Francis daCosta, “Rethinking the Internet of Things: A Scalable Approach to ConnectingEverything”, 1 st Edition, Apress Publications, 2013

SKILLS:

- Understand the fundamentals of IoT, including its physical and logical design.
- Learn about IoT hardware platforms such as Arduino, ESP8266, and Raspberry pi.
- Interface sensors like dht11, ultrasonic, and PIR with microcontrollers
- Analyze Internet Principles, Communication Protocols, and M2M architecture

Image source: OpenAI, *A Conceptual Illustration of the Internet of Things (IoT)*, AI-generated image, DALL·E, 2022



(SUBJECT CODE) – MEMS & NEMS: DESIGN AND FABRICATION

Hours per week:

L	T	P	SL	C
2	2	2	2	4

PREREQUISITE KNOWLEDGE: Solid-State Physics, Semiconductor Devices, Engineering Materials

COURSE DESCRIPTION AND OBJECTIVES:

Course Description:

This course provides a comprehensive understanding of **Microelectromechanical Systems (MEMS) and Nanoelectromechanical Systems (NEMS)**, their fabrication technologies, and design principles. It covers fundamental concepts, scaling laws, transduction mechanisms, and device modeling. Students will gain hands-on experience with simulation tools for designing and analyzing MEMS/NEMS device.

Course Objectives:

1. Develop a strong understanding of fundamental principles and applications of MEMS/NEMS.
2. Analyze scaling laws, material properties, and fabrication techniques in micro and nano systems.
3. Design and simulate MEMS sensors and actuators using industry-standard simulation tools.
4. Evaluate transduction mechanisms and actuation methods through design exercises.
5. Address integration, packaging, and reliability challenges through case studies and hands-on practices.

MODULE-1

12L+12P+12SL=36 Hours

UNIT-1: INTRODUCTION TO MEMS & NEMS

Overview, Definitions, Comparisons, Advantages & Limitations, Applications (automotive, biomedical, aerospace, telecommunications), Scaling Laws (geometry, electromagnetic forces, fluid mechanics, heat transfer)

UNIT-2: MEMS FABRICATION TECHNOLOGIES

Photolithography, E-beam Lithography, Deposition Techniques (CVD, PVD, ALD), Etching Techniques (wet etching, dry etching – RIE, DRIE, plasma etching), Micromachining Processes (bulk micromachining, surface micromachining, LIGA, MUMPS)

TRANSACTIONS:

- Calculate the critical dimensions of a MEMS structure using scaling laws.
- Analyze and compare the resolution limits of photolithography and e-beam lithography.
- Determine optimal deposition parameters for uniform thin films in CVD processes.
- Evaluate differences in etch profiles between wet etching and dry etching (RIE/DRIE).
- Compare bulk micromachining versus surface micromachining for a given MEMS sensor design.

PRACTICES:

- Simulate a photolithography process to observe the impact of exposure parameters.
- Perform a deposition process simulation to study film uniformity and growth rate.
- Design and simulate an etching process to analyze etch profiles under different conditions.
- Develop a MEMS device layout design.
- Simulate a complete fabrication sequence (lithography, deposition, etching) with varying parameters.

MODULE-2

18L+18P+18SL=54 Hours

UNIT-1: MICRO SENSORS & ACTUATORS

Acoustic Wave Sensors, Vibratory Gyroscopes, Capacitive Pressure Sensors, Thermal Actuators, Piezoelectric Actuators, Shape Memory Alloy Actuators, Electrostatic Actuation, Case Study: Piezoelectric Energy Harvester

UNIT-2: NANO DEVICES AND QUANTUM MECHANICS

Atomic Structures, Energy Levels, Quantum Mechanics (Schrödinger Equation), Nano Devices (ZnO Nanorod-based Gas Sensors), Applications of Carbon Nanotubes and Graphene in NEMS

UNIT-3: PACKAGING, MODELING & SIMULATION

MEMS Packaging (hermetic sealing, wafer-level packaging, flip-chip technology), Modeling & Simulation (Finite Element Analysis), Simulation Tools (COMSOL, ANSYS, CoventorWare, IntelliSuite), Case Study: RF MEMS Switch

TRANSACTION HOURS:

- Analyze performance metrics of a capacitive MEMS pressure sensor.
- Compute the resonant frequency and sensitivity of a vibratory gyroscope.
- Derive a quantum mechanical model for a ZnO nanorod-based gas sensor.
- Compare force outputs and response times of piezoelectric, electrostatic, and thermal actuators.
- Evaluate design trade-offs in MEMS packaging (hermetic sealing versus wafer-level packaging).

PRACTICES:

- Design and simulate a MEMS capacitive pressure sensor to assess its performance.
- Model a MEMS actuator and compare different actuation techniques.
- Perform Finite Element Analysis (FEA) of a MEMS structure.
- Model a nano sensor based on ZnO nanorods, incorporating quantum effects.
- Simulate an RF MEMS switch to evaluate switching speed, reliability, and performance.

COURSE OUTCOMES

CO No.	Course Outcome	Bloom's Level	Mapping with POs
1	Understand fundamental principles, scaling laws, and applications of MEMS/NEMS.	Understand	1
2	Analyze and apply fabrication techniques and material properties in MEMS/NEMS design.	Analyze	1, 5
3	Design and simulate MEMS sensors and actuators using industry-standard simulation tools.	Apply	1, 2, 3, 5
4	Evaluate transduction mechanisms and actuation methods through design exercises.	Evaluate	1, 3, 4, 5, 7
5	Address integration, packaging, and reliability challenges in MEMS/NEMS devices.	Evaluate	1, 2, 3, 5, 6, 7

Mapping of SDGs and IKS

Sustainable Development Goals (SDGs)	Indian Knowledge System (IKS)
SDG 3 (Good Health and Well-being)	Yes
SDG 9 (Industry, Innovation, and Infrastructure)	
SDG 11 (Sustainable Cities & Communities)	

TEXTBOOKS

1. Marc Madou, Fundamentals of Microfabrication, CRC Press, 1997.
2. Stephen D. Senturia, Microsystem Design, Kluwer Academic Publishers, 2001.

3. Tai-Ran Hsu, MEMS and Microsystems: Design and Manufacture, Tata McGraw-Hill, 2002..

REFERENCE BOOKS:

1. Chang Liu, Foundations of MEMS, Pearson Education India, 2006.
2. Sergey Edward Lyshevski, MEMS and NEMS: Systems, Devices, and Structures, CRC Press, 2002.
3. J.W. Gardner & V.K. Vardan, Micro Sensors MEMS and SMART Devices, John Wiley, 2002.
4. N. Maluf, Introduction to Micro Mechanical Systems Engineering, Artech House, 2000.

SKILLS

- Apply and analyze fundamental principles and scaling laws in the design and assessment of MEMS/NEMS devices.
- Evaluate and optimize microfabrication techniques and material properties to enhance device performance.
- Design, simulate, and analyze MEMS sensors and actuators using industry-standard simulation tools.
- Analyze and evaluate transduction mechanisms and actuation methods to ensure effective device operation.
- Synthesize integration, packaging, and reliability strategies to overcome challenges in MEMS/NEMS systems.

22ECXXX – Advanced Digital System Design with HDL

Hours per week:

L	T	P	SL	C
2	0	2	3	3

\

PREREQUISITE KNOWLEDGE: Digital Electronics, FPGA Based System Design.

COURSE DESCRIPTION AND OBJECTIVES:

To introduce students to advanced design methodologies and practical design approaches for high-performance applications. Students will design and implement a complete sophisticated digital system application, simulating and verifying the design with test benches, and synthesizing and implementing these designs with HDL

MODULE-1

12L+0T+12P+12SL=36 Hours

UNIT-1:

Data-path sub-systems

N-bit Parallel Adder/Subtractor, Carry Look Ahead Adder, 4-Bit Magnitude Comparator Unsigned Array Multiplier, Booth Multiplier, Wallace Multiplier.

UNIT-2:

Sequential System Design

Synchronous Sequential Design: Design flow, FSM, State Diagram, ASM chart, few case studies.
Asynchronous Sequential Design: FSM, Flow Table, Analysis, few case studies.

PRACTICES:

- Design of Parallel Adder/Subtractor
- Design of Carry Look Ahead Adder/Carry Save Adders
- Design of Array Multiplier/ Booth Multiplier
- Design of Sequence detector

MODULE-2

18L+0T+18P+18SL=54 Hours

UNIT-1: FSM Design

Design of Vending Machine, Elevator, Synchronous and Asynchronous FIFO, LFSR.

UNIT-2: Implementation of Protocols
Introduction to protocols, Implementation of I2C, UART.

Unit 3: RTL to GDSII
Logic Synthesis, Logic Optimization, Static Timing analysis, Clock and I/O Constraints, Clock Tree Synthesis, Verification and Testing.

PRACTICES:

- Design of Vending Machine
- Design of Elevator
- Design of Vending LFSR
- Design of FIFO
- Implementation of UART
- Implementation of I2C

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Module No.	Mappingwith POs
1	Design and implement advanced data-path sub-systems such as adders, multipliers, and comparators using HDL.	Apply	1	1, 2, 3, 5, 9, 10
2	Analyze and develop synchronous and asynchronous sequential circuits, including FSM-based system designs.	Analyze	1	1, 2, 3, 5, 9, 10
3	Develop and implement serial communication protocols like UART and I2C for embedded systems.	Apply	2	1, 2, 3, 4, 5, 6, 7, 9, 10
4	Implement real-world applications using FSM-based digital design techniques (e.g., Vending Machine, Elevator, Sequence Detector).	Apply	2	1, 2, 3, 4, 5, 9, 10
5	Understand and perform RTL to GDSII flow, including logic synthesis, timing analysis, and verification techniques.	Understand	2	1, 2, 3, 4, 5, 6, 7, 9, 10

SDGs	IKS
SDG 8 (Decent Work and Economic Growth) SDG 9 (Industry, Innovation, and Infrastructure) SDG 11(Sustainable Cities and Communities) SDG 12 (Responsible Consumption and Production)	

Text Books:

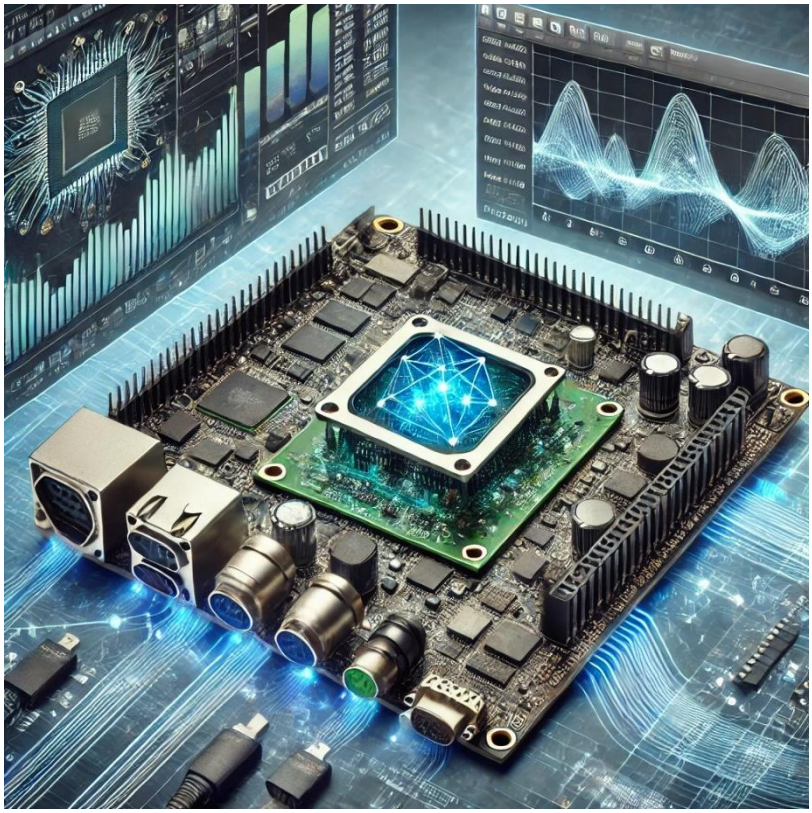
1.Michael D Ciletti, Advanced Digital Design with the Verilog HDL, Prentice Hall, Second Edition, 2017.
2.Wayne Wolf, FPGA Based System Design, Prentices Hall Modern Semiconductor Design Series, 2011.

Reference Books:

1. Ming-Bo Lin, Digital Systems Design and Practice: Using Verilog HDL and FPGAs, Create Space Independent Publishing Platform, Second Edition, 2015.
2.Digital System Design with FPGA: Implementation Using Verilog and VHDL by CemUnsalan, Bora Tar, ISBN: 9781229837906, McGrawHill Publications.
3.Designing with Xilinx FPGAs using Vivado, Editor, Sanjay Churiwala, Springer 2016.
4.Charles H Roth Jr, Lizy Kurian John and ByeongKil Lee Digital Systems Design using Verilog, Cengage Learning, First Edition, 2016.
5. Steve Keckler and oliver Franza, Asynchronous Circuit Design, Wiley, Second Edition, 2004.
6.Chris J Myers, Asynchronous Circuit Design, Wiley, Second Edition, 2004.
7.ZviKohavi and Niraj K.Jha, "Switching and Finite Automata Theory", 3rd edition, Cambridge University Press, 2010.
8. M.J.S. Smith, "Application-specific integrated circuits", Addison-Wesley, 1997.
9.NPTEL course, VLSI Design Flow: RTL to GDS, https://onlinecourses.nptel.ac.in/noc23_ee137/preview

SKILLS:

- Digital Circuit Design & FSM Implementation using HDL.
- Develop Verilog/VHDL code, testbenches, and verify digital circuits for functional correctness.
- Implement protocols and perform RTL synthesis, timing analysis, and optimization for FPGA designs.



22ECXX – TESTING OF VLSI CIRCUITS

Hours per week:

L	T	P	SL	C
3	0	2	3	4

PREREQUISITE KNOWLEDGE: VLSI Design.

COURSE DESCRIPTION AND OBJECTIVES:

This course imparts knowledge on various types of faults, fault detection techniques and dominance. The objective of this course is to introduce the student to the concepts of test generation for combinational and sequential circuits and other VLSI circuit testing methods like DFT schemes, BIST and BILBO.

MODULE-1

18L+0T+12P+18SL=48 Hours

UNIT-1: DIGITAL VLSI TESTING:

Introduction to Digital VLSI Testing, Functional and Structural Testing, Fault Equivalence, Fault dominance, Fault Simulation, Fault Models and Testability Measures.

UNIT-2: TEST GENERATION TECHNIQUES:

Introduction to Automatic Test Pattern Generation (ATPG) and ATPG Algebras, D Algorithm, PODEM, FAN, Test Generation for Sequential Circuits, Scan-Based Testing, BIST (Built-in Self-Test), Scan Chains and Scan Design

PRACTICES:

- Design and simulate logic gates. Perform fault simulations (stuck-at faults). Test the gates using fault models and check for correct operation.
- Simulate a given circuit with faults and analyze the test coverage. Implement and analyze test patterns for stuck-at faults using ATPG (Automatic Test Pattern Generation).
- Design and simulate different types of flip-flops (D, JK, T). Create test benches and simulate timing and functional behavior. Perform fault analysis on sequential circuits.
- Apply D-algorithm or PODEM (Path-Oriented Decision Making) algorithm to generate test vectors. Verify the test vectors on the designed circuit. Perform fault simulation to check test coverage.

MODULE-2

27L+0T+18P+27SL=72 Hours

UNIT-1: DESIGN FOR TESTABILITY (DFT):

Introduction to DFT, Need for DFT in VLSI, Scan Design: Full Scan, Partial Scan, and Scan Flip-Flops

UNIT-2: TESTABLE DESIGN ARCHITECTURES:

Pattern Generators, Estimation of test length, Test points to improve testability, Analysis of aliasing in linear compression, BIST methodologies, BIST for delay fault testing, Testable

memory design, Test algorithms, Test generation for embedded RAMs, Structural Testing Techniques, Testable Fault Models, Test Pattern Compression.

UNIT-3: FAULT DIAGNOSIS:
Logical level diagnosis, Diagnosis by UUT reduction, Fault diagnosis for combinational circuits, Self- checking design, System level diagnosis.

PRACTICES:

- Design a BIST circuit using a test pattern generator (TPG) and output response analyzer (ORA). Simulate the BIST functionality and analyze the test coverage.
- Insert scan flip-flops into a design and implement scan chains. Generate scan test patterns for fault simulation. Perform DFT (Design for Test) analysis on the scan-based design.
- Apply delay fault models and perform simulations to check the circuit's robustness. Analyze the delay fault coverage and test patterns.
- Implement multiplexers and de-multiplexers. Verify their functionality by applying test patterns. Perform fault simulation for possible stuck-at faults.
- Apply ATPG algorithms to generate optimal test patterns. Perform functional and fault simulation using the generated patterns. Analyze test coverage and detect faults in the design

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Mapping with POs
1.	Apply the concept of fault models to identify the faults and fault location.	Apply	1, 2, 4, 5, 8, 9, 11
2.	Analyze the Generation of test patterns for the given combinational, sequential circuits with built in self-test.	Analyze	1, 2, 5, 8, 9
3.	Test the fault diagnosis by UUT reduction techniques in combinational circuits and systems.	Apply	1, 2, 3, 5, 8, 9
4.	Develop self-checking designs for fault tolerant systems.	Apply	1, 2, 5, 8, 9, 11

Mapping of SDGs and IKS

Sustainable Development Goals (SDGs)
SDG 9 (Industry, Innovation, and Infrastructure)
SDG 11 (Sustainable Cities & Communities)

TEXT BOOKS:

1. M.L.Bushnell and V.D.Agrawal, “Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits”, 2nd edition, Kluwer Academic Publishers, 2012.
2. M.Abramovici, M.A.Breuer and A.D. Friedman, “Digital systems and Testable Design”, 2nd edition, Jaico Publishing House, 2012.

REFERENCEBOOKS:

1. P.K. Lala, “Fault Tolerant and Fault Testable Hardware Design”, 3rd edition, Academic Press, 2012.
2. A.L.Crouch, “Design Test for Digital IC’s and Embedded Core Systems”, 5th edition, Prentice Hall International, 2009.
3. http://nptel.ac.in/courses/106103016/30.

SKILLS:

- Identify various faults in any circuit.
- Analyze different test patterns for combinational and sequential circuits.
- Design and investigate self-checking circuits.

Image source: https://study bullet.com/udemy/introduction-to- testing-of-vlsi-circuits-fault- modeling/

Image file name:



Honors

22ECXXX – MEMORY DEVICES

Hours per week:

L	T	P	SL	C
3	2	0	3	4

PREREQUISITE KNOWLEDGE: Digital Electronics, VLSI Design

COURSE DESCRIPTION AND OBJECTIVES:

This course provides an in-depth study of memory devices, covering fundamental principles, architectures, and emerging trends in memory technology. It explores the classification, operation, and performance characteristics of various semiconductor memory types. It also covers key aspects of memory subsystem design, advanced topics, security mechanisms, error correction techniques and next-generation memory innovations.

MODULE-1

18L+12T+0P+18SL=48 Hours

UNIT-1: INTRODUCTION TO SEMICONDUCTOR MEMORY

Basics of Memory systems, Classification of memory: Volatile Vs Non-Volatile, Memory Hierarchy in Computing, Semiconductor Memory Technologies Overview, RAM (SRAM, DRAM) and ROM (PROM, EPROM, EEPROM).

UNIT-2: STATIC AND DYNAMIC MEMORIES

Static RAM (SRAM): Structure, Operation, Design, and Applications; Dynamic RAM (DRAM): Structure, Operation, Refresh Mechanism, and Applications; SRAM vs DRAM Comparative Analysis

PRACTICES:

- Design of SRAM
- Design of DRAM
- Comparative Analysis of SRAM and DRAM
- Design of EPROM & EEPROM

MODULE-2

27L+18T+0P+27SL=72 Hours

UNIT-1: NON-VOLATILE MEMORY TECHNOLOGIES

Read Only Memories: ROM, PROM, EPROM, EEPROM; Flash Memory: NOR and NAND Flash; Emerging Non-Volatile Memories: FeRAM, MRAM, ReRAM; Applications of Non-Volatile Memories in Embedded Systems..

UNIT-2: ADVANCED MEMORY ARCHITECTURES AND DESIGN

Cache Memory: Concept, Mapping Techniques; Virtual Memory: Paging and Segmentation; Multi Level Memory Systems; High Density Memory Design and Power Consumption Considerations.

UNIT-3: MEMORY TESTING AND APPLICATIONS

Memory Testing and Fault Diagnosis, Security in Memory Systems (Error Correction Codes - ECC), Future of Memory Technology.
.

PRACTICES:

- Design of Flash memory
- Design of MRAM
- Design of ReRAM
- Error correction in memories

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Mapping with POs
1.	Understand the Fundamentals of Memory Systems	Understand	1, 2, 5
2.	Analyze Semiconductor Memory Technologies	Analyze	1, 2, 3, 4, 5, 11
3.	Apply Memory Subsystem Design Principles	Apply	1, 2, 3, 5, 11
4.	Develop Skills in Memory Testing and Security	Create	1, 2, 3, 5, 11

Mapping of SDGs and IKS

Sustainable Development Goals (SDGs)	Indian Knowledge System
SDG 8 (Decent Work and Economic Growth)	**No**
SDG 9 (Industry, Innovation, and Infrastructure)	

TEXT BOOKS:

4. Jacob, B., Ng, S., & Wang, D, "Memory Systems: Cache, DRAM, Disk, Morgan Kaufmann, 2007.
5. Sharma, A.K, "Semiconductor Memories: Technology, Testing and Reliability, Wiley, 1997.
6. William D. Brown & Joe Brewer, "Nonvolatile Semiconductor Memory Technology: A Comprehensive Guide to Understanding and using NVSM Devices, Wiley-IEEE Press, 1997.

7. Betty Prince, “High Performance Memories: New Developments and Future Directions, Wiley, 1999.

REFERENCEBOOKS:

17. Kartikeya Pande and Bapiraju Vinnakota, “Computer Memory Design and Testing, Prentice Hall, 1996.
18. Fujio Masuoka**,** “Non-Volatile Memory Technologies with Emphasis on Flash, Wiley, 2010.

SKILLS:

- Understand various semiconductor memory architectures.
- Ability to analyze different memory technologies based on speed, power, and cost.
- Design of memory modules and subsystems.

Image source: https://www.dreamstime.com/stock-photo-memory-devices-image11426270

Image file name:



22XXXXX – ANALOG IC DESIGN

Hours per week:

L	T	P	SL	C
3	0	2	3	4

\

PREREQUISITE KNOWLEDGE: Analog Circuits, VLSI Design.

COURSE DESCRIPTION AND OBJECTIVES:

This course covers the analysis and design of analog integrated circuits starting from basic building blocks to different implementations of the amplifiers in CMOS technology.

MODULE-1

18L+0T+12P+18SL=48 Hours

UNIT-1: CMOS Device Fundamentals and Current Mirrors:

CMOS Device Fundamentals: Basic MOS models, device capacitances, parasitic resistances, substrate models, transconductance, output resistance, frequency dependence of device parameters.

Current Mirrors: CMOS current mirror, Source degenerated current mirror, High output impedance current mirrors.

UNIT-2: Single stage amplifiers:

Common source amplifier, common drain amplifier or source follower, Common gate amplifier, Cascode gain stage, MOS differential pair, Differential Amplifiers.

PRACTICES:

Design and simulate the following analog circuits.

- Verify the characteristics of nMOS and pMOS devices.
- Current Mirror and Cascode Current Mirror circuits
- Common Source, Common Drain and Common Gate Amplifiers
- Differential Amplifier

MODULE-2

27L+0T+18P+27SL=72 Hours

UNIT-1: Frequency Response of Amplifiers:

Miller effect, Common Source amplifier, Source follower amplifier, Common gate amplifier, Cascode gain stage.

UNIT-2: Noise in Amplifiers

Introduction to noise in electronic circuits, Types of noise: Thermal noise, shot noise, flicker (1/f) noise, Noise models of resistors and MOS transistors, Input-referred noise and output noise calculations, Noise in single-stage and multi-stage amplifiers.

UNIT-3: CMOS Operational Amplifiers:
Classification of Op Amps, Design of one stage and two stage Opamps, Gain boosting techniques, Folded cascode amplifier, Telescopic cascode amplifier and Common mode feedback (CMFB) amplifier, Opamp specification analysis, stability, and frequency compensation.

PRACTICES:

Design and simulate the following analog circuits.

- CMOS Op-amp single Stage
- Two stage operational amplifier
- Folded cascode amplifier
- Telescopic cascode amplifier

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Module No.	Mappingwith POs
1	Design basic building blocks of analog ICs.	Understand	1	1, 9
2	Design optimal single stage amplifiers for various applications	Apply	1	1, 3, 5, 9
3	Modelling circuits with noise elements	Apply	2	1, 3, 9
4	Analyze the frequency response of amplifiers	Analyze	2	1, 2, 3, 5, 9
5 5	Develop a procedure for optimal compensation of op-amp against process, supply and temperature variations	Apply	2 2	1, 2, 5, 9,11

Sustainable Development Goals (SDGs)	Indian Knowledge System
SDG 8 (Decent work and economic growth)	**No**
SDG 9 (Industry, Innovation, and Infrastructure)	

TEXT BOOKS:

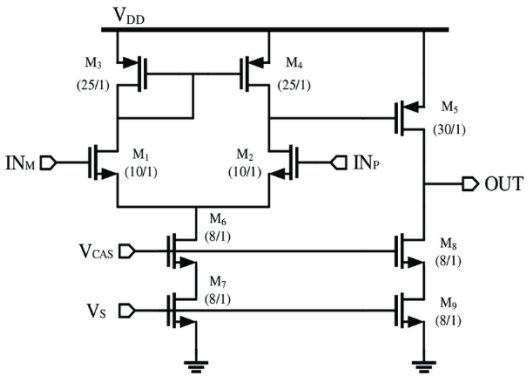
1. Behzad Razavi, “Design of Analog CMOS integrated circuits”, McGraw-Hill International edition, 2001.
2. D. A. Johns and Martin, Analog Integrated Circuit Design, John Wiley,1997.

REFERENCE BOOKS:

1. R Gregorian and G C Temes, Analog MOS Integrated Circuits for Signal Processing, John Wiley,1986.
2. R L Geiger, P E Allen and N R Strader, VLSI Design Techniques for Analog & Digital Circuits, McGraw Hill,1990.
3. Gray, Wooley, Brodersen, “Analog MOS Integrated circuits”, IEEE press,1989.
4. Alan B. Grebene, “Bipolar and MOS Analog Integrated Circuit Design”, Wiley, 2002.

SKILLS:

- Identify and analyze various Current mirror circuits.
- Design of differential amplifier.
- Analyze the frequency response of amplifiers.



https://www.planetanalog.com/wp-content/uploads/Fig-1-OTA-ResearchGate.png

22ECXXX – Digital IC Design

Hours per week:

L	T	P	SL	C
2	0	2	2	3

\

PREREQUISITE KNOWLEDGE: Digital Electronics, VLSI Design.

COURSE DESCRIPTION AND OBJECTIVES: This course bridges circuits and system-level digital design, starting with CMOS inverter and advancing to complex digital circuits in line with modern technology trends. With a strong focus on design, it begins with basic specifications and builds up to system-level blocks.

MODULE-1

12L+0T+12P+12SL=36 Hours

UNIT-1: DESIGN OF CMOS INVERTER

CMOS Inverter: Introduction to MOS transistor, V-I Characteristics, Electrical Parameters, Static behavior, switching Threshold, Noise Margins, Robustness revisited, Dynamic behavior: Computing the capacitances, propagation delay, propagation delay from a design perspective, power, energy and energy delay.

UNIT-2: DESIGN OF CMOS COMBINATIONAL CIRCUITS

Combinational Logic Design: Introduction, Static CMOS Design: Complementary CMOS, ratioed logic, pass transistor logic dynamic CMOS Design: Dynamic logic, speed and power dissipation of dynamic logic, signal integrity issues in Dynamic design, cascading dynamic gates.

PRACTICES:

- Design of Inverter and all logic gates
- Design and Simulation of Full adder
- Design and Simulation of Serial Binary Adder, Carry Look Ahead Adder.
- Design of pseudo logic gates
- Design of DCVSL logic gates

MODULE-2

18L+0T+18P+18SL=54 Hours

UNIT-1: DESIGN OF CMOS SEQUENTIAL CIRCUITS

Sequential Logic Design: Introduction, static latches and registers: The Bi-stability principle, multiplexer based latches, master-slave edge-Triggered register, low-voltage static latches, Static SR Flip-flop, dynamic latches and registers, dynamic transmission, Gate Edge - triggered registers, CMOS NORACMOS True single - phase clocked register (TSPCER).

UNIT-2: TIMING ANALYSIS

Timing Issues in Digital Circuits: Introduction, Timing classification of digital systems, synchronous design, Self-Timed circuit design, synchronizers and arbiters**.**

UNIT-3: DESIGNING ARITHMETIC BUILDING BLOCKS AND MEMORIES

Datapaths in digital processor architecture, adder, vedic multiplier, shifter, ROM, nonvolatile Read-Write memories, SRAM, DRAM, CAM

PRACTICES:

- Design of static flip flops
- Design of dynamic shift register
- Design of edge triggered registers
- Design of D flipflop using TSPCER
- Design of adder
- Design of multiplier
- Design of shifter
- Design of SRAM cell
- Design of DRAM cell

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Module No.	Mappingwith POs
1	Design CMOS inverters with specified noise margin and propagation delay.	Apply	1	1,2,5, 9,10
2	Implement efficient techniques at combinational circuit level for improving power and speed of digital circuits	Apply	1	1,2,3,4,5, 9,10
3	Design CMOS sequential circuits	Apply	2	1,2,3,4,5, 9,10
4	Analyze timing constraints in VLSI systems.	Understand	2	1,2,3,5, 9,10
5	Design arithmetic circuits and memories	Apply	2	1,2,3,4,5, 9,10

SDGs	IKS
SDG 7 (Affordable and Clean Energy) SDG 9 (Industry, Innovation, and Infrastructure)	Vedic Mathematics

TEXT BOOKS:

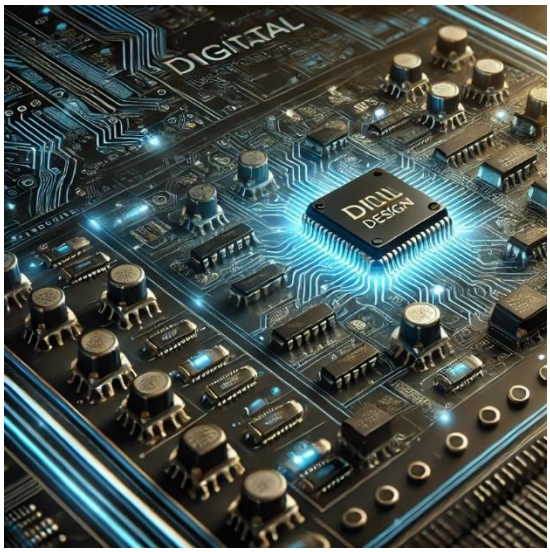
1. Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic., Digital Integrated Circuits: A Design Perspective, Second Edition, Pearson Education India, 2003
2. Ken Martin, Digital Integrated Circuit Design, Oxford University Press, 1st edition, 1999.

REFERENCE BOOKS:

1. Neil H. E. Weste and D. M. Harris, CMOS VLSI Design, Third Edition, 2010. 2. Sung-Mo Kang, CMOS Digital Integrated Circuits, 3rd Edition, McGraw-Hill, 2003.
2. IEEE Trans Electron Devices, IEEE J.Solid State Circuits, and other National and International Conferences and Symposia.

SKILLS:

- Identify various cmos logics to design combinational circuits.
- Design CMOS based sequential circuits.
- Analyze the timing constraints in the VLSI designs.



22XXXXX – ASIC DESIGN

Hours per week:

L	T	P	SL	C
3	2	0	3	4

PREREQUISITE KNOWLEDGE: VLSI Design.

COURSE DESCRIPTION AND OBJECTIVES:

To prepare the student to be an entry-level industrial standard ASIC or FPGA designer. To give the student an understanding of issues and tools related to ASIC/FPGA design and implementation. To give the student an understanding of basics of System on Chip and platform-based design.

MODULE-1

18L+12T+0P+18SL=48 Hours

UNIT-1: INTRODUCTION TO ASICS

Types of ASICs, Design flow, CMOS transistors, CMOS Design rules, Combinational logic Cell, Sequential logic cell, Transistor as Resistors, Transistor parasitic capacitance, Logical effort, Library cell design, Library architecture.

UNIT-2: Programmable ASICs

Anti fuse, Static RAM, EPROM and EEPROM technology, PREP benchmarks, Actel ACT, Xilinx LCA, Altera FLEX, Altera MAX DC & AC inputs and outputs, Xilinx I/O blocks.

Practices

- Logic effort
- Design SRAM Cell.
- Analyze different ROM memories.
- Comparative analysis of programmable ASICs

MODULE-2

27L+18T+0P+27SL=72 Hours

UNIT-1: TRADE OFF ISSUES AT SYSTEM LEVEL

Optimization with regard to speed, area and power, asynchronous and low power system design. ASIC physical design issues, Power Dissipation.

UNIT-2: ASIC physical design

System Partitioning, Partitioning Methods, ASIC floor planning, Placement and Routing.

UNIT-3: HIGH PERFORMANCE ALGORITHMS FOR ASICs AS CASE STUDIES

Canonic Signed Digit Arithmetic, KCM, Distributed Arithmetic, High performance digital filters for sigma-delta ADC.

PRACTICES:

- Design memories using different power reduction techniques.
- Analyze different floor planning techniques.

- Analyze different placement techniques to optimize area.
- Analyze different routing techniques to optimize speed.
- Canonic Signed Digit Arithmetic
- KCM

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	**Recognize the need for programmable devices and demonstrate VLSI tool-flow**	Understand	1	1
2	**Able to utilize FPGA architecture**	Apply	1	1, 2, 3, 5
3	**Identify** the issues involved in ASIC design, including technology choice, design management, tool-flow, verification, debug and test, as well as the impact of technology scaling on ASIC design.	Apply	2	1, 2, 4, 5, 11
4	**Develop** the algorithms used for ASIC construction.	Apply	2	1, 2, 3, 5, 11
5	**Analyze** high performance algorithms available for ASICs IC.	Analyze	2	1, 2, 3, 11

Sustainable Development Goals (SDGs)	Indian Knowledge System
SDG 8 (Decent work and economic growth)	**No**
SDG 9 (Industry, Innovation, and Infrastructure)	

TEXT BOOKS:

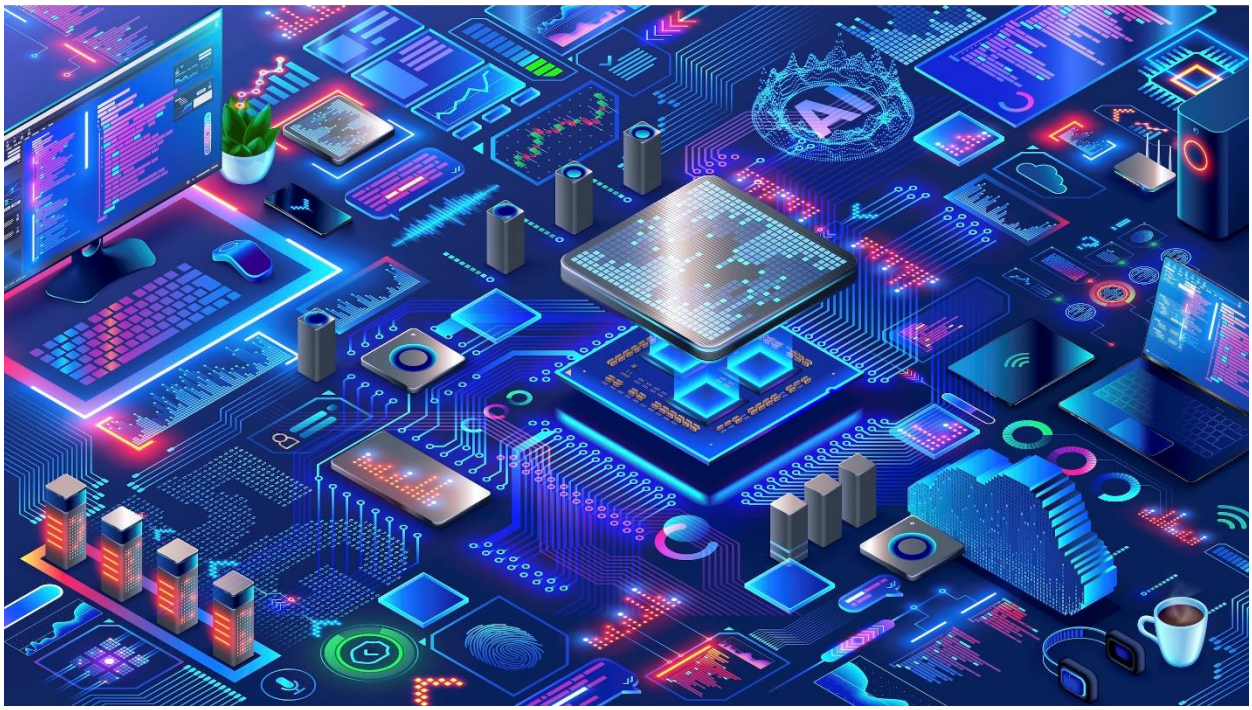
1. M.J.S. Smith,"ApplicationSpecific Integrated Circuits", Pearson, 2003
2. H.Gerez, "Algorithms for VLSI Design Automation", John Wiley,1999.

REFERENCE BOOKS:

1. J..M.Rabaey, A. Chandrakasan, and B.Nikolic, "Digital Integrated
2. D.A.Hodges,"AnalysisandDesignofDigitalIntegratedCircuits(3/e)",MGH2004.
3. Hoi-Jun Yoo, KangminLeeandJun Kyong Kim, "Low-Power NoC for High-Performance SoC Design", CRC Press,2008.

SKILLS:

- Design and verification techniques of digital ASICs.
- Apply knowledge on ASIC design flow.



https://www.sondrel.com/blog/why-thinking-about-software-and-security-is-so-important-right-at-the-start-of-an-asic-design

xxxxxxx – Nano Electronic Devices Modelling

L	T	P	SL	C
3	2	0	3	4

PREREQUISITE KNOWLEDGE: Basic knowledge of Solid-State Devices and VLSI

COURSE DESCRIPTION AND OBJECTIVES:

The goal of this course is to provide an insight into the fundamentals of Nanoscience and nanotechnology. The course provides basics of nanomaterials, quantum mechanics and statistical mechanics

MODULE-1

UNIT-1: Introduction to Nanotechnology [18L+12T+0P+18SL=48 Hours]

Importance and opportunities at the nanoscale, Length and time scales in nanostructures, Classification of nanostructures, Limitations of conventional microelectronics, Low-dimensional structures: Quantum wells, wires, and dots; Overview of Carbon Nanotubes (CNTs) and Graphene, Trends in microelectronics and optoelectronics

UNIT-II: Basic of Quantum Mechanics

Introduction to Quantum Mechanics - Schrodinger equation – time dependent and time independent equations. Solutions of the Schrodinger equation – free particle - particle in a box – one and three dimensions - particle in a finite well - Penetration through a barrier – Tunnel effect – Single step barrier.

TRANSACTIONS:

- Introduction to Nanotechnology & Its Importance
- Analyze Quantum Structures & Low-Dimensional Materials
- Solve Fundamentals of Quantum Mechanics & Schrodinger Equation with boundary conditions
- Solve particle in a 1-D box problem & Tunneling Phenomen

MODULE-2

UNIT-I : Mathematical Modelling for Electron

[18L+12T+0P+18SL=48 Hours]

Modelling: Charge transport in nanostructures under an electric field: Parallel and perpendicular transport, Hot electrons and quantum transport, Coulomb blockade effect, ; Charge transport in a magnetic field: Aharonov-Bohm effect, Shubnikov-de Haas effect, Quantum Hall effect

UNIT-II: Modelling for Electronics Device

MOSFETS, heterojunction bipolar transistors, Resonant tunnel effect, RTD, RTT, Hot electron transistors, Coulomb blockade effect and single electron transistor, CNT transistors,

UNIT-III: Modelling for Optoelectronics Device

Heterostructure semiconductor laser, Quantum well laser, quantum dot LED, quantum dot laser, Quantum well optical modulator, quantum well sub band photo detectors, principle of NEMS.

Course Outcomes

At the end of the course, the students should be able to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	**The** students will be able to understand basic concepts of nanoelectronics devices and nano technology	Understanding	1,2	1,2,3,4,11
2	To understand and familiarize the quantum, Mechanics.	Understanding	1,2	1,2,3,4,11
3	To provide the recent advancement of fabrication technologies	Application	1,2	1,3,4,5,11
4	To provide basic understanding of nanoelectronics devices.	Analysing	1,2	1.3,4,9,11

Mapping of SDGs and IKS

Sustainable Development Goals (SDGs)	Indian Knowledge System
SDG 9 (Industry, Innovation, and Infrastructure)	**No**
SDG 12 (Responsible Consumption and Production)	
SDG 7 (Affordable and Clean Energy)	

Skills:

- Understanding of Nanoelectronics & Quantum Mechanics
- Mathematical & Computational Modelling
- Device Physics & Design
- **Problem-Solving & Analytical Thinking**
- Application in Emerging Technologies

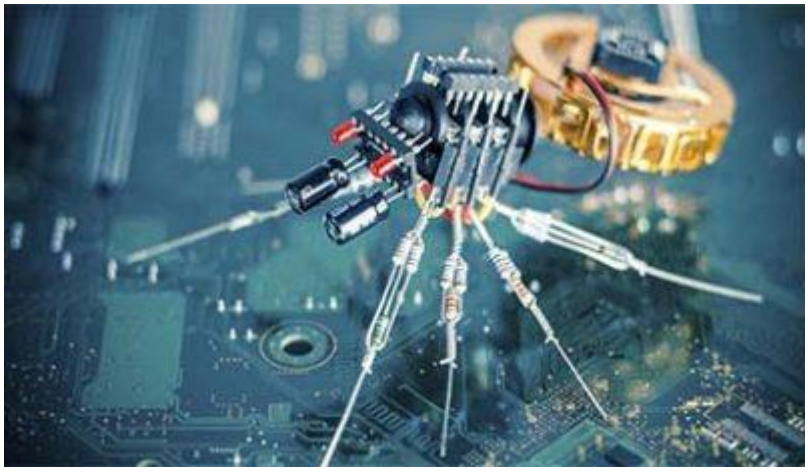
Books and References

Text Book:

1. T. Pradeep —A textbook of Nanoscience and Nanotechnology, Tata McGraw – Hill education private ltd, 2012.
2. David. J, Griffiths, —Introduction to Quantum Mechanics", Pearson, 2009.

References

1. Chattopadhyay, Banerjee, Introduction to Nanoscience & Technology, PHI, 2012
2. George W. Hanson, Fundamentals of Nanoelectronics, Pearson Education, 2009.
3. K. Goser, P. Glosekotter, J. Dienstuhl, Nanoelectronics and nanosystems, Springer 2004.



https://www.google.com/search?q=picture+define+Nano+Electronic+Devices++Modelling&sca_esv=91bf622baf105a74&udm=2&biw=1366&bih=641&ei=EzTlZ8ztHOrC4-EP59jckAc&ved=0ahUKEwiMw_jukaqMAxVq4TgGHWcsF3IQ4dUDCBE&uact=5&oq=picture+define+Nano+Electronic+Devices++Modelling&gs_lp=EgNpbWciMXBpY3R1cmUgZGVmaW5lIE5hbm8gRWxlY3Ryb22pYyBEZXZpY2VzICBNb2RlbGxpbmdI2AlQ9wJY9wJwAXgAkAEAmAFroAFrqgEDMC4xuAEDyAEA-AEC-AEBmAIAoAIAmAMAiAYBkgcAoActsgcAuAcA&sclient=img#vhid=4T8gtlszK8ywdM&vssid=mosaic

22 EC XXX: Photovoltaic Device & Energy Conversion

L	T	P	SL	C
3	2	0	3	4

PREREQUISITE KNOWLEDGE:

- Semiconductor Physics, Electronics Device and Circuits

Course Description

- Learn fundamentals of solar cell technology
- Understand the working physics of different types of solar cells

Module 1

Unit-I: Fundamental of Solar cell-1 [18L+12T+0P+18SL=48 Hours]

Semiconductors and junctions, I-V characteristics of p-n junctions. Solar Cell Structure, Light generated Current, Light IV Characteristics, Solar cell parameters, Spectral Response and Quantum Efficiency, Effect of Series Resistances and Shunt Resistances on solar cell I-V characteristics, Effect of Temperature and Light Intensity, effect of shading, Losses in solar cells

Unit-II: Fundamental of Solar cell-2:

Generation recombination in semiconductors; Shockley, Read and Hall expression; Surface and interface recombination; Schockley-Queissser limit of efficiency

Transactions

- Understanding the fundamentals of solar energy conversion
- Analyzing the effects of material properties on PV performance
- Understanding semiconductor physics relevant to solar cells

Module-2

Unit-I: Manufacturing of solar cells: [18L+12T+0P+18SL=48 Hours]

Cell Fabrication Technologies, Screen Printed Solar Cells, Buried Contact Solar Cells, High Efficiency Solar Cells, Rear Contact Solar Cells, Silicon Source Material, Wafers, Cleaning, Texturing, Diffusion, Plasma Ed RE Isolation, Anti- Reflection Coating, Screen-Printed front and rear contact,

Unit-II: Testing of silicon solar cells

Testing and Module fabrication, Solar simulator, measurement of efficiency of solar cell, External quantum efficiency (EQE) and Internal quantum efficiency (IQE) measurement, Quantum efficiency analysis, Lifetime measurement

Unit-III: Advanced Solar Cell

Organic solar cell:- Fundamentals and fabrication, Perovskite:- Fundamentals and fabrication technique, Dye synthesis solar cell:- Fundamentals and fabrication.

Transactions: -

- Fabrication and testing of PV devices
- Performance evaluation and loss analysis
- Understanding degradation mechanisms in PV systems
- Fabrication of perovskite solar cell

Course Outcomes

At the end of the course, the students should be able to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Students will gain knowledge of: the device physics of solar cells, the operating principles of the major commercial photovoltaic technologies.	Apply	1,2	1,3
2	Current challenges and primary areas of research within the field of photovoltaics, and a basic understanding of the role of photovoltaics in the context of the global energy system	Create	1,2	6,7,8,11
3	Student understand the fundamental and working of c-Si solar cell.	Understanding	1,2	1,2
4	Student can understand the new generation solar cells like organic, perovskite and dye-synthesis solar cell	Understanding	1,2	4,5
5.	Students can understand the fabrication steps of these advanced solar cells.	Understanding	1,2	3,5,8

Mapping of SDGs and IKS

Sustainable Development Goals (SDGs)	Indian Knowledge System
	No
SDG 9 (Industry, Innovation, and Infrastructure)	
SDG 12 (Responsible Consumption and Production)	
SDG 7 (Affordable and Clean Energy)	

Skills:

- **How solar cell works**
- **How to fabricated solar**
- **Types of solar cells**

Books and References

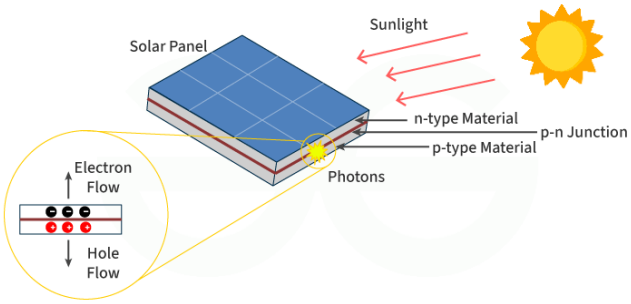
Text Book:

3. Solanki Chetan singh, Solar Photovoltaics,: Fundamentals, Technologies and Applications, ISBN-978-81- 203-3760-2, PHI Learning Pvt. Ltd., New Delhi

4. Bansal N.K., Photovoltaics Systems, ISBN 81-901296-0-0, Omega Scientific Publishers, New Delhi, 2003
5. Brendel R., Thin Film Crystalline Solar Cells: Physics and Technology, Wiley-VCH, Verlag GmbH and Company, Weinheim Germany, 2003
6. J N Roy and D N Bose: Photovoltaic Science and Technology, Cambridge University Press, 2018 Solid State Electronic Devices, Ben G Streetman & Banerjee

References

4. Green M.A., Silicon solar Cells: Advance Principles and Practices, Bridge RE Printrey, Sydney,1995
5. Green M.A., Solar Cells: Operating Principles, Technology and system Applications, Prentice Hall Incl. Engelwood Cliffs N.J., USA, 1982



https://www.google.com/search?sca_esv=91bf622baf105a74&q=picture+define+Photovoltaic+Device+%26+Energy+Conversion&udm=2&fbs=ABzOT_CWdhQLP1FcmU5B0fn3xuWpA-dk4wpBWOGsoR7DG5zJBkzPWUS0OtApxR2914vrjk60CMaA0jPMd-1UByCaBk9RKJ4HEp1SDb4A8RXo1r1hGBfiKMSt_TMxeT9qIWOfrkTRcZEbvkPWAxvKnVoYamBSvzGShNGtazFU2DO1kvSzHlpcsPhEz9nmyhBcxJuVzH5dxhZ9s2OSjJOnu3mNia_ntJzH8Q&sa=X&ved=2ahUKEwjmk7frkaqMAxVQzzgGHXXKBy8QtKgLegQIExAB&biw=1366&bih=641&dpr=1#vhid=PW3GpQIieSGByM&vssid=mosaic

22VLXXXX– LOW POWER VLSI DESIGN

Hours per Week:

L	T	P	SL	C
3	2	2	2	4

PREREQUISITE COURSE: Basic VLSI Design, AICD & DICD.

COURSE DESCRIPTION AND OBJECTIVES: To understand the critical requirements and implementation of Low-power VLSI circuits. The course also covers critical issue related to continuous scaling of microelectronic circuits.

MODULE-1 **[12L+12T+12P+12SL=48 Hours]**

UNIT-1

Fundamentals of Low Power VLSI Design: Basic Principle of Low Power Design, Need for Low Power Circuit Design

Sources of Power Dissipation: Switching Power Dissipation, Short Circuit Power Dissipation, Leakage Power Dissipation, Glitching Power Dissipation

Short Channel Effects: Drain Induced Barrier Lowering and Punch Through, Surface Scattering, Velocity Saturation, Impact Ionization, Hot Electron Effect.

UNIT-2

For achieving low power: Hierarchy of Limits of Power, Switching activity reduction,

Power Optimization: Algorithmic Power optimization, Logic Level Power Optimization – Circuit Level Low Power Design – Gate Level Low Power Design –Architecture Level Low Power Design

Different logic styles: Static and dynamic logic, Clock gating, reducing glitching through path balancing, input reordering.

PRACTICES:

Design and simulate the logic circuits implementing the following low power techniques.

- ♣ VTCMOS.
- ♣MTCMOS
- ♣ Transistor stacking.
- ♣ Power gating.

MODULE-2 **[18L+18T+18P+18SL=72 Hours]**

UNIT-1

Low-Voltage Low-Power Design Techniques: Reducing Power Consumption in Combinational Logic, Sequential Logic, Trends of Technology and Power Supply Voltage, Low-Voltage Low-Power Adders, Low-Voltage Low-Power Multipliers.

UNIT-2

Low-Voltage Low-Power Memories: Basics of ROM, Low-Power ROM Technology, Future Trend and Development of ROMs, Basics of SRAM, Memory Cell, Pre-charge and Equalization Circuit, Low Power SRAM Technologies, Basics of DRAM, Self-Refresh Circuit, Future Trend and Development of DRAM.

UNIT-3

Synthesis And Software Design for Low Power CMOS Circuits: Synthesis for Low Power – Behavioural Level Transform –Algorithms for Low Power – Software Design for Low Power.

PRACTICES:

- ♣ Design and simulate the following circuits.
- ♣ Low-Voltage Low-Power Adders
- ♣ Low-Voltage Low-Power Multipliers
- ♣ Low power SRAM
- ♣ Self-refresh circuit of DRAM

SKILLS:

- To design and analyse low power and low voltage circuits.
- To implement existing low power techniques to various designs.
- Able to develop new techniques to reduce power.

ACTIVITIES:

- Implement advanced low power techniques.
- Design of advanced adders and multipliers.
- Improve efficiency of memories in terms of power.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Acquires knowledge about the second order effects of MOS transistor characteristics.	Understanding	1	1, 2, 4, 5, 8, 9, 11
2	Analyse various CMOS low power design techniques and apply these approaches to various logic circuits.	Analyze	1	1, 2, 3, 4, 5, 8, 9
3	Design and implementation of computational structures for low power applications	Apply	2	1, 2, 3, 5, 8, 9
4	Analyse memories with efficient architectures to improve power.	Analyze	2	1, 2, 3, 5, 11
5	Synthesis the software design	Evaluate	2	6, 8, 11

Mapping of SDGs and IKS

Sustainable Development Goals (SDGs)
SDG 9 (Industry, Innovation, and Infrastructure)

TEXT BOOKS:

1. CMOS Digital Integrated Circuits – Analysis and Design – Sung-Mo Kang, Yusuf Leblebici, TMH, 2011.
2. Low-Voltage, Low-Power VLSI Subsystems – Kiat-Seng Yeo, Kaushik Roy, TMH Professional Engineering.
3. Anantha P. Chandrakasan, and Robert W. Brodersen, Low Power Digital CMOS Design, Kluwer Academic Publications, 1995.

REFERENCES:

1. Kaushik Roy and S.C.Prasad, "Low Power CMOS VLSI Circuit Design", Wiley, 2000
2. J.B.Kulo and J.H Lou, "Low Voltage CMOS VLSI Circuits", Wiley 1999.
3. James B.Kulo, Shih-Chia Lin, "Low Voltage SOI CMOS VLSI Devices and Circuits", John Wiley and Sons, Inc. 2001
4. J.Rabaey, "Low Power Design Essentials (Integrated Circuits and Systems)", Springer, 2009.
5.Practical Low Power Digital VLSI Design – Gary K. Yeap, Kluwer Academic Press, 2002.

22EC--- THIN FILMS CHARACTERIZATION

Hours per week:4

L	T	P	SL	C
2	2	2	2	3

PREREQUISITE KNOWLEDGE: Semiconductor Physics and Devices

COURSE DESCRIPTION AND OBJECTIVES:
To understand about the difference between bulk and thin film, the optical, electrical, dielectric and magnetic properties of thin film, the theories explaining the formation of thin film and the fabrication and advantages of thin film devices.

MODULE-1

12L+12T+12P+12SL=48 Hours

UNIT-1: Thin Films and their preparation methods

Thin films versus thick films, Physical methods of preparation of thin films- Thermal evaporation, Cathodic sputtering, Molecular beam epitaxy and Laser ablation methods.
Chemical methods of thin film preparation- Electrolytic deposition, Chemical vapor deposition.

UNIT-2: Thickness measurement and characterization
Electrical, Mechanical, Optical, Microbalance, Quartz crystal methods, Analytical techniques of characterization of film thickness: X-ray diffraction, Electron microscopy, High and low energy electron diffraction, Auger emission spectroscopy.

PRACTICES:

- Calculate the deposition time and energy consumption for a 3 μm thick film with a 0.05 nm/s rate and 220 W power.
- Find the deposition rate in nm/s with a sputtering yield of 0.3 atoms/ion and 0.5 A current.
- Calculate the deposition rate and thickness after 5 hours with a flux of 5×10^{12} atoms/cm²·s and a sticking coefficient of 0.8.
- Determine the energy delivered for 1 μm thickness with 5 mJ/pulse and 10 Hz frequency, 50% efficiency.
- Find the mass of the film deposited in 1 hour with 0.3 A current, 1.5 nm/min rate, and 85% efficiency.
- Calculate the mass of material deposited in 30 minutes with a flow rate of 100 sccm and 0.2 μm/min rate.
- Calculate film thickness and mass for an 80 Hz frequency shift using QCM with a sensitivity factor of 0.22 nm/Hz.
- Find the d-spacing and film thickness for a peak at $2\theta = 28.5°$ with 1.54 Å wavelength.
- Calculate the actual film thickness at 100 nm and 600 nm from a 200,000x magnified 5 mm image.
- Determine adjusted thickness after 10 minutes of sputtering with 0.5 nm/min rate and 15% fluctuation.

MODULE-2

18L+18T+18P+18SL=72 Hours

UNIT-1: Growth and Structure of Films
General Features of thin films, Nucleation theories, Effect of electron bombardment on film structure, Post-nucleation growth, Epitaxial film growth, Structural defects.

UNIT-2: Mechanical, Optical and Electrical Properties of Thin Films
Mechanical properties: Elastic and Plastic behavior.
Optical properties: Reflectance and transmittance spectra, Absorbing films, Optical constants of film material, Multilayer films, Anisotropic and isotropic films.
Electrical properties: Conductivity in metal, Semiconductor and Insulating films, Discontinuous films, Superconducting films.

UNIT-3: Magnetic Properties of Thin Films and Thin Film Devices
Molecular field theory, Spin wave theory, Anisotropy in magnetic thin films, Domains in thin films, Applications of magnetic thin films. Thin film devices: Fabrication and applications.

PRACTICES:

- Calculate nucleation density at 600 K, given $N_0=10^{21}$ cm^{-3}, $E_a=1.5eV$, and T=600 K.

- Calculate the growth rate at 450 K with R_0=0.02 nm/s, T_0=300 K, and n=1.5.
- Calculate the misfit strain for a substrate with a_s=3.2 A˚ and film material a_f=3.3 A˚.
- Find the number of vacancies in 1 cm² for a film subjected to 10 keV electrons generating 2×10^{-4} vacancies/cm^2.
- Calculate the stress for a 0.005 tensile strain in copper with E=120 GPa and σ_y=220 MPa.
- Calculate the reflectance for a silicon film on glass with n=3.5 and thickness 500 nm.
- Calculate the absorbance of a 200 nm gold film with an absorption coefficient of 1.8×10^4 cm^{-1} at 550 nm.
- Calculate the optical path difference for a 3-layer stack of materials with refractive indices 2.0, 1.5, and 2.5 and 100 nm thickness.
- Calculate the resistance of a 2 cm² square copper film of 100 nm thickness with resistivity 1.6 μΩ·cm.
- Calculate the critical current density for a 50 nm thick lead superconducting film with a bulk critical current density of 10^5 A/cm^2.
- Calculate the Curie temperature for a 50 nm thick ferromagnetic film with $J=1.2\times10^{-21}$ J and, N=10^{28} spins/m^3.
- Calculate the energy to excite a spin wave with wavevector k=1.5 nm^{-1} in a film with $D=5\times10^{-3}$ J/m.
- Calculate energy density for a film with $K_u=1.0\times10^5$ J/m^3 and magnetization perpendicular to the easy axis.
- Calculate domain wall thickness in a 200 nm thick magnetic film with wall energy density 2.5×10^{-3} J/m^2.
- Calculate the change in resistance per unit thickness of a 10 μm thick magnetic sensor with a 0.1% resistance change at 0.5 T.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Mapping with POs	Relevant SDGs
1.	Explain thin film preparation techniques, including physical and chemical deposition methods.	Remember, Understand	1, 2	4
2.	Analyze various methods for measuring thin film thickness and their characterization using advanced techniques.	Understand, Analyze	2, 3	9
3.	Apply nucleation theories and post-nucleation growth concepts to understand thin film structures.	Apply, Evaluate	3, 5	12

4.	Investigate the mechanical, optical, and electrical properties of thin films and their significance in material science.	Understand, Apply	2, 4	7
5.	Examine the magnetic properties of thin films and their applications in modern thin film devices.	Analyze, Apply	4, 6	9
6.	Explore the fabrication and applications of thin film devices in electronics and emerging technologies.	Understand, Evaluate	5, 11	11

TEXT BOOKS:

6. K.L. Chopra, "Thin Film Phenomena", First Edition, McGraw-Hill, 1969.

REFERENCEBOOKS:

19. George Hass, "Physics of Thin Films", Volumes 1, Academic Press Inc., 1963.
20. R.W. Berry, P.M. Hall and M.T. Harris, "Thin Film Technology", Van Nostrand, 1968.
21. L. I. Maissel and Glang, "Handbook of Thin Film Technology", McGraw Hill Higher Education, 1970.

SKILLS:

- Learn various thin film deposition methods and their effects on film properties.
- Use tools like XRD, EM, and QCM to measure and analyze thin film thickness and quality.
- Understand nucleation, post-nucleation growth, and epitaxial growth processes.
- Analyze the mechanical, optical, electrical, and magnetic properties of thin films.
- Design and apply thin films in devices for electronics, optics, and magnetism.

xxxxxxx- HARDWARE/SOFTWARE CO-DESIGN

Hours per week:

L	T	P	SL	C
2	2	2	2	4

PREREQUISITE KNOWLEDGE: Computer Architecture.

COURSE DESCRIPTION AND OBJECTIVES:

To analyze and explain the control-flow and data-flow of a software program and a cycle based hardware description. To transform simple software programs into cycle-based hardware descriptions with equivalent behavior and vice versa. To identify performance bottlenecks in a given hardware-software architecture and optimize them by transformations on hardware and software components.

MODULE-1

UNIT-1: ISSUES IN CO-DESIGN AND SYNTHESIS [12L+8T+0P+12=20 Hours]

Co- Design Models, Architectures, Languages, A Generic Codesign Methodology. Hardware software synthesis algorithms: hardware – software partitioning distributed system co-synthesis.

UNIT-2: PROTOTYPING & EMULATION [12L+8T+0P +12=20 Hours]

Prototyping and emulation techniques, prototyping and emulation environments, future developments in emulation and prototyping architecture specialization techniques, system communication infrastructure, Architecture Specialization techniques, System Communication infrastructure.

Practices

- Interfacing Memory to the Processor.
- Interfacing Processor with Peripherals.
- Interfacing a Robot Axis position Control to Processor.

MODULE-2

UNIT-1: COMPILATION TECHNIQUES ANS TOOLS FOR EMBEDDED PROCESSOR ARCHITECTURES [12L+8T+0P=20 Hours]

Modern embedded architectures, embedded software development needs, compilation technologies practical consideration in a compiler development environment.

UNIT-2: LANGUAGES FOR SYSTEM –LEVEL SPECIFICATION AND DESIGN

[12L+8T+0P=20 Hours]

System – level specification, design representation for system level synthesis, system level specification languages. Heterogeneous specifications and multi-language co-simulation. Introduction to Cosyma system and LYCOS system.

Practices:

- Study of FPGA Design Test Methodology.
- UART for Software Testing.
- Study of FPGA Hardware Testing Methodology.

SKILLS:

- Use Simulation software to co-simulate software programs with cycle-based hardware description.

ACTIVITIES:

- Design Cosyma & Lycos.
- Simulate cycle based hardware.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to:

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	**Identify** CO Design models.	Apply	1	1, 2, 11
2	**Compare** architecture of control & Data dominated system.	Apply	1	1, 2, 4, 5, 11
3	**Analyze** tools for processor architecture.	Apply	2	1, 2, 3, 5, 11
4	**Design** Cosyma & Lycos system	Create	2	1, 2, 3, 11

Mapping of SDGs and IKS

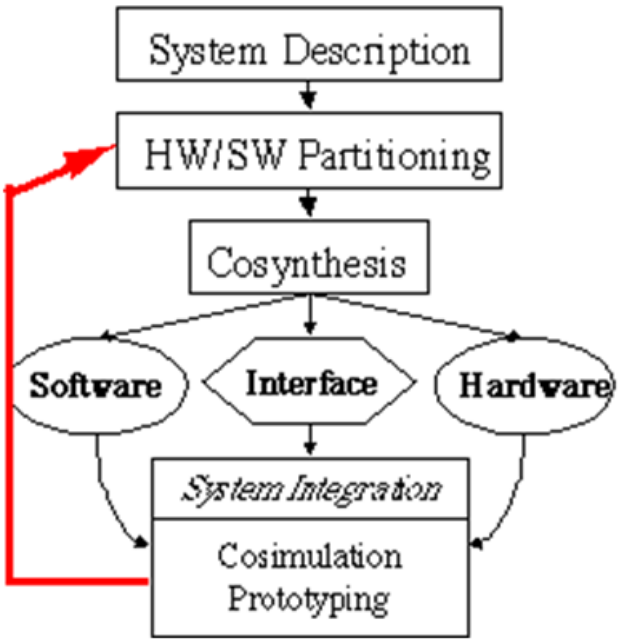
Sustainable Development Goals (SDGs)	Indian Knowledge System
SDG 4 (Quality Education)	**No**
SDG 9 (Industry, Innovation, and Infrastructure)	
SDG 12 (Responsible Consumption and Production)	

Text Books:

1. Jorgen Staunstrup, Wayne Wolf, "Hardware / software co- design Principles and Practice", Springer, 2009.
2. Kluwer, "Hardware / software co- design Principles and Practice", academic publishers,2002.

Reference Books:

1. Rahul Dubay Introduction to Embedded System Design Using Field Programmable Gate Arrays, 2009 Springer-Verlag London Limited.
2. Frank Vahid & Tony Givargis, Embedded System Design, A Unified Hardware/Software Introduction, ISBN 978-0-471-38678-0 2014.



https://www.cs.ubc.ca/wccce/program98/micaela/micaela.html

22EC102 – NEUROMORPHIC COMPUTING

Hours per week:

L	T	P	SL	C
3	2	0	3	4

PREREQUISITE KNOWLEDGE: Neural Networks and Learning Machines, Basic Python programming knowledge, Electronic Devices and Circuits, Analog Electronics.

COURSE DESCRIPTION AND OBJECTIVES:

Describe the basic principles of neuromorphic computing and how they differ from traditional computer architectures and computing paradigms, the introduction to hardware elements belongs to the neuromorphic devices and circuits perspective.

MODULE-1

18L+12T+0P+18SL=48 Hours

UNIT-1: HARDWARE SPIKING ARTIFICIAL NEURONS, THEIR RESPONSE FUNCTION, AND NOISES

Introduction, Biological Neurons, Neuronal Response Function, Neuronal Noises, Artificial Neuron Models, Hardware Spiking Neurons, Silicon Neurons, Emerging Spiking Neurons.

UNIT-2: SYNAPTIC PLASTICITY WITH MEMRISTIVE NANODEVICES

Introduction, Neuromorphic Systems: Basic Processing and Data Representation, Synaptic Plasticity for Information Computing, Synaptic Plasticity Implementation in Neuromorphic Nanodevices.

TRANSACTIONS:

- Analyze Artificial Neuron Models.
- Analyze Hardware Spiking Neurons.
- Analyze Emerging Spiking Neurons..
- Analyze Synaptic Plasticity for Information Computing.

MODULE-2

18L+12T+0P+18SL=48 Hours

UNIT-1: NEUROMEMRISTIVE SYSTEMS: A CIRCUIT DESIGN PERSPECTIVE

Introduction: Taking a Cue from Nature, Memristor Overview, Voltage Versus Current-Mode Circuit Designs for NMSs, Neuron Circuits: Primary Information Processing Units, Synapse Circuits: Communication and Memory, Plasticity Circuits: Adaptation/Learning.

UNIT-2: REINTERPRETATION OF MAGNETIC TUNNEL JUNCTIONS AS STOCHASTIC MEMRISTIVE DEVICES

Introduction, Magnetic Tunnel Junction Basics, MTJs as Stochastic Synapses, Multiple Binary OxRAMs as Synapses for Convolutional Neural Networks.

UNIT-3: NONVOLATILE MEMORY CROSSBAR ARRAYS FOR NON-VON NEUMANN COMPUTING

Introduction, Considerations for a Crossbar Implementation, phase-Change Memory (PCM): Results, on-filamentary RRAM Results, Novel Biomimetic Si Devices for Neuromorphic Computing Architecture.

TRANSACTIONS:

- Analyze neuromorphic hardware systems.
- Analyze Magnetic Tunnel Junctions.
- Analyze phase-Change Memory.

COURSE OUTCOMES:

Upon successful completion of this course, students will have the ability to

CO No.	Course Outcomes	Blooms Level	Module No.	Mapping with POs
1	Analyze Artificial Neuron Models.	Analyze	1	1, 2, 11
2	Analyze Hardware Spiking Neurons.	Analyze	1	1, 2, 4, 5, 11
3	Implement neuromorphic circuits with the memristor.	Apply	2	1, 2, 3, 5, 11
4	Implement neuromorphic circuits with magnetic tunnel junction devices.	Apply	2	1, 2, 3, 11

Mapping of SDGs and IKS

Sustainable Development Goals (SDGs)	Indian Knowledge System
SDG 4 (Quality Education)	**Yes**
SDG 9 (Industry, Innovation, and Infrastructure)	
SDG 12 (Responsible Consumption and Production)	

Skills

- Understanding of Spiking Neural Networks (SNNs)
- Neuromorphic Hardware Design & Analysis
- Synaptic Plasticity & Learning Mechanisms
- Memristor & Magnetic Tunnel Junction (MTJ) Applications
- Non-Von Neumann Computing & Crossbar Arrays

TEXT BOOKS:

1. Suri, Manan, ed. *Advances in neuromorphic hardware exploiting emerging nanoscale devices*. Vol. 4. New Delhi: Springer, 2017.
2. Skills & Activities:



https://www.google.com/search?sca_esv=36ca69732928f54b&q=NEUROMORPHIC+COMPUTING+picture&udm=2&fbs=ABzOT_CWdhQLP1FcmU5B0fn3xuWpA-dk4wpBWOGsoR7DG5zJBkzPWUS0OtApxR2914vrjk7XZXfnfKsaRZouQANLhmphNyg6d7jx9WIegRytfuMfNwBSLAX8WsvrJKa122pJHUIlKMc2yoT7_B9lgToWPwNbYpl_7_yklqe1wm0fpdTBIoqGWsPpb22UD3UvjWoU4fKL0lYhJnvgBdjvGwiuHZD5yuMTWg&sa=X&ved=2ahUKEwjD1ZyBgaqMAxVMR2wGHTJEFOcQtKgLegQIEhAB&biw=1366&bih=641&dpr=1#vhid=pqBN8ku-NoqXZM&vssid=mosaic